Realities of Transdisciplinary Research Development in Uganda Co-evolution of Knowledge in Triple Helix Processes

Peter Okidi-Lating

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© Makerere University 2011 Publisher: Makerere University Press, Kampala, Uganda Graphic Design, Typesettning and Printing: Mixiprint, Sweden 2011 ISBN 9970-05-040-X

Foreword

This book is addressing valuable knowledge in technical as well as nontechnical education resources for social economic development in rural areas. The book is directed towards policymakers, academics as well as private and public sector actors in developing countries. Situated knowledges in the form of detailed stories are presented in order to firmly ground the results and recommendations given.

The author, Dr Peter Okidi-Lating, was motivated to write this book from his wish to bring out his reflections of, ideas in and experiences of carrying out action research. His research was strictly disciplinary at the beginning of his research project but coevolved into triple helix processes.

The impact of recruiting students to higher education in Uganda mainly from secondary schools in Kampala and its nearby surroundings has been identified as a problem in the development process of Uganda. The problem increases with the fact that the number of female university students is far lower than male students especially in knowledge areas of engineering and technology. The latter are affecting us all and our daily lives and thus possibilities for sustentation. In order to encounter the needs in society in a relevant and sustainable way, when it comes to technical and other solutions, an equal gender representation in higher education and research is fundamental.

In Uganda there has been a number of policy interventions aimed at improving female students participation in Makerere University. In 1990/91, 1.5 bonus marks were awarded to every female student joining a public tertiary institution. Makerere started admitting private students for undergraduate programmes in 1992/3 and now 80% of students are private in the university. The number of students on Government sponsorship was doubled from the 2001 academic year from 2000 to 4000 students. More female students joined universities through that avenue. In 2005, after realising that rural schools were not sending students for higher education, Government came up with a formula for sharing the 4000 places sponsored by the State:

3000 places were given on academic merit with 75% going to science-based courses and the remaining 25% is shared by Arts and Humanities.

The other 1000 places to be given to Districts (11 places per District). With 81 Districts, this totals to 891 places. The balance is given to special interest groups like sportsmen and people with disabilities.

Government intends to sponsor 2,000 more students in Universities from 2011/12 academic year. This will bring the total number of students on state sponsorship to 6,000.

In 2001/2, Makerere University, with support from Carnegie Corporation of New York, established a Female Scholarship Scheme, FSI, with the sole purpose of enhancing enrolment, retaining and improving academic performance of female undergraduate students at Makerere University. The Scheme targeted female students who were

admitted to mainly science disciplines and those from financially disadvantaged backgrounds. 70% of the fund went to Science Disciplines and 30% to Humanities. The scheme was operated up to 2006/7 academic year.

The above policies have helped to increase female students' enrolment in Makerere University for 24% in 1989 to 45.8% in 2008 and 51% by 2010.

However, the increase in enrolment is not uniform in all the Departments and Units of Makerere University. For example, enrolment of female students in Faculty of Technology has remained low at an average of 17.2 %. The majority of the female students are from advantaged, elite, urban schools. Over 90% of the female students in the Faculty of Technology come from schools located in only three Districts in Uganda: Kampala (the capital city) and its surrounding educationally elite Districts of Wakiso and Mukono. Uganda had 81 Districts then, most of them rural and poor. Now there are 112 of them and the number is increasing.

It means that all the policy interventions have not improved enrolment of female students into the Faculty of Technology. It can be concluded that rural A-Level schools do not perform well enough in the two essential engineering subjects –Physics and Mathematics. That is why they do not gain admission into universities for engineering courses because they do not meet the minimum requirements to join the university. Arua was found to be one such district, where never a female student has been sent on merit for engineering training for the last couple of years.

The research frame base of this book is constituted by the author's PhD studies conducted at Makerere University, Uganda and Blekinge Institute of technology, BTH, Sweden during 2005 - 2009. The provisional research topic was titled: The effects of E-learning applications in rural secondary education in Uganda on performance of female students in Mathematics and Physics.

The main supervisor was Dr. Samuel Baker Kucel of Mechanical Engineering Department, Faculty of Technology, Makerere University. Currently, Dr Samuel Baker Kucel is the Deputy VC of the newly established public university in Eastern Uganda, Busitema University. The second supervisor was Professor Lena Trojer from the Division of Technoscience Studies, BTH.

Dr Lating did his research with financial support of Sida/SAREC to Makerere University, Faculty of Technology, Engineering Mathematics Division under the sub-programme 6 research theme: ICT/GIS for Sustainable Rural Development in the Lake Victoria Region.

Kampala 5th of February 2011 Lena Trojer, Professor BTH

Acknowledgement

I would like to acknowledge Sida/SAREC for the financial support for my PhD research activities in rural Uganda. I am also grateful to my supervisors, Dr Samuel Baker Kucel from Makerere University, Uganda and Professor Lena Trojer from Blekinge Institute of Technology, Sweden.

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Abbreviations

AFSAT	African Satellite Communications Company. It is an Internet Service
AIDS-	Acquired Immune Deficiency Syndrome
A-LEVEL	Advanced Secondary Education and is appointed by the Central
	Government) and Research
B.Sc.	Bachelor of Science Degree
BTH	Blekinge Institute of Technology
CAO	Chief Administrative Officer. The accounting officer of a District in
	Uganda
CBO	Community Based Organizations
CD-ROM	Compact Disc – Read Only Memory
DED	German Development Service
DEO	District Education of Officer
DFID	UK Department for International Development
DRC	Democratic Republic of Congo
DVD	Digital Versatile Disk
FM	Frequency Modulation
GDP	Gross Domestic Product
GIS	Geographical Information System
GNI	Gross National Income
GTZ	German Technical Corporation (The Deutsche Gesellschaft für Technische
	Zusammenarbeit)
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
I@MAK	Innovations at Makerere University
IBM	International Business Machines
ICC	International Criminal Court
ICT	Information and Communications Technology
ICTSRD	ICT for sustainable Rural Development
IPR	Intellectual Property Rights
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IT	Information Technology
JEBET	Journal of Engineering, Built Environment and Technology
KTP	Knowledge Transfer Partnerships
KVA	Kilo Volt Ampere
LABE	Literacy and Adult Education
LC5	Local Council 5 (The political head of a District in Uganda).
LRA	Lord's Resistance Army
MAK	Makerere University. Sometimes erroneously abbreviated as MUK.
MB	Mega Byte
MDG	Millennium Development Goal
MOES	Ministry of Education and Sports
MSI	Millennium Science Initiative
MTN	Mobile Telecommunications Network
MTTI	Ministry of Trade, Tourism and Industry
NABL	National Agricultural Biotechnology Laboratory
NARO	National Agricultural Research Organization
NaSARRI	Serere National Semi-Arid Resource Research Institute
NCDC	National Curriculum Development Centre

NEPAD	New Partnership for Africa's Development
NGOs	Non Governmental Organizations
NSEA	Needs Service Education Agency
NTC	National Teachers' College
NUFFIC	Netherlands Organization for International Cooperation in Higher
	Education
NUSAF	Northern Uganda Action Fund
O-LEVEL	Ordinary Secondary Education
PEAP	Poverty Eradication Action Plan
PGDE	Post Graduate Diploma in Education
PMA	Plan for Modernization of Agriculture
PRDP	Peace, Recovery and Development Program Provider in Uganda
PSI	Private Sector Initiative
PTA	Parents and Teachers Association
PV	Photovoltaic
R&D	Research and Development
S5	Senior Five
S6	Senior Six
SAREC	Swedish Agency for Research Cooperation with Developing Countries
SEK	Swedish Currency
SEG	School Facilitation Grant
SNV	Netherlands Development Organization
STEM	Science, Technology, Engineering and Mathematics
STI	Science Technology and Innovations
UDSM	University of Dar es Salaam
UEM	Eduardo Mondlane University
UGAPRIVI	Uganda Association of Private Vocational Training Institutions
UGX	Uganda Shillings
UK	United Kingdom
UN	United Nations
UNEB	Uganda National Examinations Board
UNESCO	United Nations Educational Scientific and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
UNIDAS	A Spanish catholic NGO
UNIDO	United Nation Industrial Development Organization
UNRE	Uganda National Rescue Front
LIPE	Universal Primary Education
LIPS	Uninterruptible Power Supply
	United State of America
USD	United States Dollar
USE	Universal Secondary Education
UTI	Uganda Telecommunications Limited
VAT	Value Added Tax
VSAT	Varue Fuddet Tax Very Small Aperture Terminal
WENRECO	West Nile Rural Electrification Company
WNIRE	WEST Nile Bank Front
WINDI	World Summit on the Information Society
W/W/W/	World Wide Web
vv vv vv	WOHL WILL WED

Chapter 1 – INTRODUCTION

An applied action research done in the social context of application and implication of the research findings can only be transdisciplinary. My doctoral study in Makerere University, Uganda, co-evolved into transdisciplinary research.

1.1. Introductory Remarks about Uganda

Uganda was a British protectorate from 1894 until October 9th, 1962 when it attained independence. The population of the country is estimated to be 31.8 millions with an annual growth rate of over 3.2 % (Uganda Bureau of Statistics, 2010). This is one of the highest population growth rates in the world. The average number of births per woman in Uganda is 6.7; an indicator of a very high fertility rate.

The structure of the Ugandan population is not suitable for increased productivity. The majority of the people are below 18 years and up to 49% of the population is below the age of 15- a non-working population. Labour force in the country was estimated at 11.5 million persons in 2009/10 reflecting an increase of two million persons from 9.5 million in 2005/2006. This gives an annual labour force growth rate of 4.7% which is well above the 3.2% average population growth rate.

There is a lot of pressure on the Uganda Government to provide employment opportunities for the fast-increasing working population. Like any other developing country, Uganda is struggling with an acute problem of unemployment and under-employment. Under – employed people are those who have formal jobs but earn less than what is required to propel them out of poverty. The labour force has remained principally rural at 82% and the structure of the labour force is also worrying. By 2010, the labour force without formal schooling was 17%, the proportion of those with primary/ basic education was 53% and those with degrees and above was only 20%. Kampala District with the rest of the Central Region has the highest proportion of the working population standing at 30% while Northern Uganda has the least share of only 19%. In terms of development in Uganda, Northern and Eastern Uganda lag far behind the Central and Western regions. Up to 76% of the labour force is self employed mainly in subsistence, non-commercial agriculture. This is an indication of low growth in the formal economy and high rate of job creation in the informal economy. In circumstances where a large proportion of the employed is constituted of contributing family workers is a probable indicator of poor development, limited job creation, widespread poverty and a large rural economy. This explains why the working population that is in paid employment is only 24%.

The uncontrolled population growth puts a lot of strain on the social services delivery, particularly on education, health, housing, water and sanitation, security and infrastructure like electricity, roads, telecommunications and railways. Growth in the social services delivery is slower than that of the population. Urbanization is low with nearly 82% of the population living in rural areas where they practice traditional, nonmechanised, subsistence agriculture as a means of survival. This has led to very low quality of life especially of rural communities. It is also worth noting that the majority of the population in urban areas is the poor. For example, Kampala, the capital city, has 90% of its population being poor and living in crowded slums with hardly any social services being delivered to them. This is not surprising since Uganda has a population comprising 68% that is non-monetised (a population that lives purely a subsistence life). Such a population complete the whole year without touching money. This means most of the Ugandan population is not bankable. Banks are stuck with money since the population is not motivated to borrow from them.

The Ugandan economy is not the command type like that in Cuba, North Korea and China. The country moved away from a mixed economy (UK model) to a free market one which is private-sector led (USA model). In the early 1990s, Uganda Government fully liberalized the economy and divested its interests from doing business. Public corporations like railways, airlines, hotels, banks, cooperatives and marketing boards were privatized. The market forces now control the economy with minimum regulation by the State. A market economy is based on demand and supply of products and services. Prices are determined depending on supply and demand. It is the prices that act as a signal to the producers and consumers. However, private sector led economies have the following disadvantages:

• It may fail to supply public goods and services like electricity and rail services to rural areas where they consider it not viable. Only 9% of Ugandans have access to electricity. After privatizing the railways, the market share of railway transport reduced to less than 3%. Most bulk cargo is transported expensively by road

- It usually fails to supply merit goods like provision of food stamps to support nutrition, the delivery of health services to improve quality of life and reduce morbidity, subsidized housing and education,
- Social costs may be ignored especially environmental degradation and pollution, destruction of forests and wetlands, etc
- It promotes inequality of wealth; the injustice in society may lead to armed conflicts
- It leads to the existence of monopolies in the economy when there is no competition. For example, electricity generation and distribution in the West Nile part of Uganda has been left to the West Nile Rural Electrification Company Limited, WENRECo. This is a monopoly in the region and there is no competition that will force it to improve its service delivery.

Despite the fact that the Ugandan economy has been growing at the rate of 6 to 8 % annually for the last two decades, the country remains one of the poorest in the world. Yet the country has the third highest growth rate of its economy in the world. This is not surprising given that 68% of the population is not monetized. By 2006, up to 31% of the population was living below the poverty line. This translated to nearly 9 million people who were depending on less than one dollar (USD) a day. There has been a further reduction in the number of people living below the poverty line to 24% by the end of 2010. Many critics do not agree with the latest statistics that reflect a very low level of poverty in the country.

Uganda Government has made several attempts to make the country develop. However, official policy is against population control. A country like Thailand spurred development of its economy by reducing the average number of children per mother from 6.5 to 2.2 within one generation. Uganda Government introduced the Decentralisation policy as a means of taking essential services closer to the ever increasing population. Smaller and smaller non-national administrative units have successively been created. Currently, Uganda is administratively divided into 112 Districts and the number is increasing after more pledges were made during presidential election campaigns in 2011 to create ten more new Districts. All the Districts in Uganda are 'decentralized' from the Central Government. However, most of the Districts are rural, remote, poor and lack financial and administrative autonomy from the Central Government. Many of them can only fund up to 2% of their budgets using their own internally generated funds. The revenue-base for districts is increasingly diminishing—with most units now heavily dependent on Central Government disbursements mainly through conditional grants. Most qualified professionals are not motivated to work in the rural Districts because of poor remuneration and hardships involved where basic social services are scanty. As a consequence, the Districts have high levels of poorly qualified local leaders with low levels of academic qualifications. Decentralization in Uganda has changed from devolution that was originally envisaged under the constitution to delegationthe weakest form of decentralization.

1.2. Concept of Development and its Measurement

In 1990, the United Nations (UN) found that measurement of development using quantitative growth in Gross Domestic Product (GDP) or Gross National Income (GNI) was 'deceptive'. It was not giving a true picture of development (well-being of the people) in a given country. The Human Development Index (HDI) was introduced as a measurement of development. This index measures poverty only in terms of education (literacy), health (especially maternal health-care improvement, infant mortality reduction and combating HIV/AIDS pandemic) and life expectancy. However, while literacy (basic education) is a necessary condition for development, it is not sufficient for stimulating development. No country has developed on the basis of basic education. We need higher education.

Uganda was ranked 143rd out of 175 countries in terms of human development with a per capita income of approximately 330 USD (according to the United Nations Development Programme report of 2010). The HDI still puts Uganda as one of the 47 countries with Low Human Development, even after successfully implementing the Decentralisation policy. The country still belongs to a group of developing countries with weak economies.

It would appear that measurement of development in terms of HDI ranking is also problematic. The ranking puts Uganda as one of the least developed countries yet the country has successfully reduced poverty from 56% in the 1990s to 24% by 2010. Vilanilam (1979) rightly observed that "development means different things to different people (and that) its meaning varies according to the changes occurring in the social, economic, political, cultural, ethical, scientific and technological value of a given society".

Economists understand development to mean an increase in production, GDP and per capita income.

Political scientists, on the other hand, take development to mean an improvement in resources through which power are equitably distributed.

For sociologists, development is the process achieved through structural differentiation, peace, order and social progress.

According to Rogers (1976) development is "a widely participatory process of social change in the society, intended to bring both social and material advancement (including greater equality, freedom and other valued qualities) for the majority of the people through their gaining control over their environment". In order to establish that a country is developing or not, pertinent questions are desirable. Seers (1977) contends that in determining a country's development, the following questions should be asked regarding:

i. What is happening to poverty? It is important to know what is happening to higher education, health and life expectancy. For example, infant mortality rate in Uganda is unacceptably high at 76 per 1,000 live births. Higher education is not being sufficiently funded by the state. Emphasis is put on basic education.

- ii. What is happening to unemployment and under-employment? Only 24% of labour force in Uganda has paid employment in the formal sector. Private sector is weak and cannot employ all the graduates from tertiary institutions(Universities and Colleges). Minmum wage in Uganda is very low thus reducing the income of the working class. While poverty in Uganda has been reduced to 24% by 2010, the poverty level in Nothern Uganda is still high, at 47%. This is more than double the national rate of poverty.
- iii. What is happening to inequality as measured by the GINI coefficient? The *Gini coefficient* is a measure of statistical dispersion developed by an Italian statistician, Corrado Gini. He published his work in his 1912 paper. The coefficient measures the degree of inequality in the distribution of family income in a country. In Uganda, the GINI coefficient has been increasing from 0.37 in 1992/93, 0.40 in 1999/2000 to 0.41 in 2005/2006 according to the National Development Plan (April 2010).

"If all three of these measures of development (poverty, unemployment and inequality) have declined from high levels, then this has been a period of development for the country concerned. If one or two of these central problems have been growing worse, especially if all three have, it would be strange to call the result "development" even if per capita income doubled" (Seers, 1977)

1.3. Role of Universities in Development

Anyone seeking to tackle the problems facing the developing world like Uganda should remember two simple facts. First, none of the problems of developing countries- hunger, diseases, and lack of sustainable economic growth- can be addressed without the use of science, technology, engineering, mathematics (STEM) and Innovations. Secondly, harnessing STEM and Innovations for development depends on the knowledge and skills of a country's people; this requires a robust and effective higher education system. It is the higher education system that can produce and sustain these skills. Unfortunately, many developing countries ignore this critical information. They put more emphasis on basic education. Yet graduates of basic education (primary and secondary levels of education) are literate but lack skills, knowledges and attitudes necessary for employment. Most of the graduates are bellow the working age and hence they cannot be used for development. Furthermore, there is no evidence that a country has ever developed because of its increased level of literacy. It is higher education that produces graduates suitable for development of the economy.

There are four reasons why universities, as components of the higher education system, are established:

- To inspire and enable individuals to develop their capabilities to the highest potential levels throughout life, so that they grow intellectually, are well equipped for work, can contribute effectively to society and achieve personal fulfillment;
- To increase knowledge and understanding for their own sake and to foster their application to the benefit of the economy and society;
- To serve the needs of an adaptable, sustainable, knowledge-based economy at local, regional and national levels; and
- To play a major role in shaping a democratic, civilized and inclusive society.

All the four reasons for establishing a university point towards one direction: development. Therefore, the core mandate of most universities is education (teaching and learning), research and community services or outreach. Universities should champion development of the economy through research which requires a lot of funding.

1.4. Funding of Higher Education in Developing Countries

A much cited World Bank study (Psacharopoulos, 1986) estimated that the social rate of return on investment in higher education was on average 13% lower than the returns from basic education in developing countries. A later review of 98 countries from 1960-1997 found that the typical social rate of return from primary schooling was 18.9%, compared to just 10.8% for higher education. In 1994, the World Bank stressed that higher education should not be prioritized in development strategies and cut its higher education spending from 17% (for the 1985-1989) to just 7% in 1985-1999. Other donors followed suit. The 2000 World Education Forum in Dakar, Senegal, confirmed the international community's neglect of higher education in the developing world, advocating only for primary education as a driver of broad social welfare improvements. Fortunately, a 2005 review by Harvard University found that higher education was missing from most African countries' poverty reduction strategies.

Uganda, for example, introduced the Universal Primary Education (UPE) in 1997 and enrolment in primary education tripled from about 2.7 millions in 1996 to 8.7 millions in 2009/2010. This level of education takes approximately 67% of the education budget of the country. This increase in enrolment has resulted in the increase of literacy levels among the population above 10 years from 69% in 2005/2006 to 73% in 2009/20010. UPE has challenges in terms of the quality of the education and low completion rates. In 2007, Uganda introduced the Universal Secondary Education (USE) for purposes of enrolling most of the UPE graduates into the next cycle of education. USE was originally meant for students in Ordinary Secondary level (O-Level) of education but from 2012, it will be extended to the Advanced Secondary level (A-Level) as well.

Another reason for neglecting higher education was the argument about 'brain drain'. Quite a number of graduates from developing countries were migrating to developed countries and get employed there. Many Governments in developing countries felt that it was a waste of time focusing on higher education.

In the last five years, several factors have combined to get higher education back on the agendas of major donors. In Yusuf and Saint (2008), it is reported that the World Bank acknowledged the need for 'a more knowledge-intensive approach to development' in Africa and admitted that such an approach requires more focus on higher education. Earlier in 2005, the Commission for Africa, set up by the UK Government, clearly suggested that the international community should recognize the value of Higher Education in development. It recommended that donors should increase investments in Africa's Higher Education capacity and urged them to provide USD 500 million a year (up to USD 3 billion over ten years) for Centres of excellence in science and technology. The World Bank/UNESCO (2000) report found that higher education in developing countries was in a 'perilous' state yet sustainable development is impossible without it. The reader is referred to the study by Bloom, Canning and Chain (2005) which concludes that increasing the stock of tertiary education by one year could maximize the rate of technological catch-up by Sub Saharan countries at a rate of 0.6 percentage points per year or 3.2 percentage points over five years.

It has been found that economic measures on the return on educational investment do not accurately reflect the social value added by higher education, which includes job creation and enhanced entrepreneurship and mobility (the ability to move across job sectors). Moreover, they ignore the positive effects of research- a core higher education activity- on the countries' economies. World Bank and major donors now realize the role of higher education in creating public knowledge, exchanging skills between industry and academia and creating better technology. Many academics attribute India's emergence on the world's economic stage to its decades-long efforts to provide high-quality, technically-oriented higher education. India established many Institutes of Technology using donor funds that they were given at the time of independence in 1947.

In the knowledge economy, higher education can help developing countries compete with more technologically-advanced societies. Countries that continue to ignore higher education will lag behind in terms of development. It is higher education that generates, stores and disseminates knowledge.

Higher education is necessary in the face of modern threats like climate change, global warming, changing disease patterns and food insecurity. It is higher education that can produce skilled labour needed to carry out and apply research in the contexts of the problems.

'Brain drain' is not now looked at negatively. Ideas have changed. Developing countries see the potential of bringing 'brains' back once they have received further training overseas. This is called 'brain circulation'. Many Governments of developing countries now see 'brain drain' as good. However, achieving 'brain circulation' relies on the ability to offer good quality research facilities in universities at home.

The Diaspora itself can lead to economic and private benefits at home. China and India have strong ties with their Diaspora. Uganda, just like other African countries, is also maintaining very strong ties with its Diaspora. There are about 757,500 Ugandans living abroad of which 39% are refugees. Despite the global economic slow down, remittances from the Ugandans in the Diaspora grew from 175 million USD in 1995, 694 million USD in 2009 and 773 million USD in 2010 (World Bank Fact Book, 2011). The same report by World Bank says that 36% of Uganda's tertiary trained population emigrates abroad- hence the term 'brain drain'.

The World Bank is not the only player in supporting higher education in developing countries now. There are bilateral donors (like SIDA, USAID, DFID, JICA, GTZ, Nuffic), multilateral donors (World Bank, European Commission, African Develop-

ment Bank) and private foundations (Bill & Melinda Gates Foundation, Carnegie Corporation, Rockefeller Foundation, Ford Foundation, etc). Many of the donors favour applied action research as opposed to basic research. They also insist that the researchers should produce socially useful results.

Most African leaders now acknowledge that adequate resources for training university scientists are essential for development. The Addis Ababa Declaration on Science, Technology and Scientific Research for Development, signed by African Union Heads of State in January 2007, states that: 'We...reaffirm ...our common objective to advance the development of the continent by promoting research in all fields, in particular in science and technology'. The signatories also pledge to 'ensure the enhanced role and the revitalization of African Universities and other African institutions of higher education, as well as scientific research institutions, so that they can play an effective role as loci of science, technology and engineering education and development'. The African heads of state pledged to dedicate 1 percent of GDP for Science and Technology and research by 2010. It is not very difficult for a group of leaders to come together and agree that something is important. The main difficulty is in the implementation of such policies.

Uganda for the very first time included Science, Technology and Innovation (STI) as a complementary chapter in its five-year National Development Plan beginning 2010/11. This implies that STI is accorded priority as a necessary tool for economic development, and would be expected to receive modest budgetary support. This process precedes Uganda government's approval of the national STI policy in 2009, and other deliberate measures it took to support STI such as the Presidential Support to Scientists. In Financial Year 2010/11 government provided additional support for value addition processes in the Faculty of Technology and Department of Food Science and Technology of Makerere University. These recent policy changes and support for STI are manifestations of a rapidly evolving innovation system in Uganda. The Presidential Innovations Initiatives proposal being supported in the Faculty of Technology includes ten key innovation projects worth USD 4.9 Million as well as vital research and training laboratory equipment worth USD 8.3 Million totaling about USD 13.2 million over the next 5 years. Earlier, Uganda Government made Science and Mathematics compulsory in all schools (basic education) in Uganda. Furthermore, the Government is implementing a policy of allocating 75% of State scholarships in public universities to students on science-based programmes. Established in 1922, Makerere University remains the single most dominant university with a relatively sound research base in Uganda. However, starting from 1989, all the four new public universities that have been established are all science-based. They are Mbarara University of Science and Technology, Kyambogo University, Gulu University and Busitema University. Due to public demand, the Government of Uganda is in the process of establishing a sixth science-based public university in the West Nile region of Uganda- the Muni University. The first students may be admitted to this university not earlier than August 2012. The Millennium Science Initiative (MSI) in Uganda offers a useful model for effective cooperation among African governments and universities, donor agencies and the international scientific community. The first phase of MSI is valued at 30 million USD and was started in 2006. The MSI is a science capacity building programme tailored to Uganda's development needs. The programme, supported by World Bank and country counterpart funds, addresses some of the challenges in Uganda's strategy for science and technology. These include producing graduates with the science and engineering skills the labour market needs, strengthening graduate education and increasing links between universities and the private sector. Other countries are encouraged to replicate such a collaborative model.

1.5. Enrolment in Universities in Uganda

There are twenty three recognized private Universities in Uganda today. Together with the five public universities, the total number of universities is twenty eight in Uganda. Enrolment in the 28 Universities in Uganda now stands at 120,000 of which 65,000 are in the five public universities and 55,000 are in the 23 private ones. The gross enrolment ratio in Universities in Uganda is less than 4.9%. This is the lowest ratio in the region. The Sub-Saharan Africa estimate is about 8% while for the far-east and developed countries- it is estimated to be between 25 to 60%. No country can develop without developing its higher education system.

Graduation patterns from universities in Uganda still show that the ratio of arts and humanities graduates to science graduates is 5:1. Still, there is a problem here. There is no critical mass of STEM graduates to spur development.

Technical skills are needed for development. In Uganda the ratio of engineers to technicians is 8:1. The country produces more graduates than technicians. Yet the ratio should be 1:5. The education system needs to change and start producing the middle cadre skilled technicians.

Development and application of technologies in society has always led to development. In the knowledge economy, application of Information and Communication Technologies (ICTs) is particularly important.

1.6. Role of ICT in Development

The 2000 Millennium Declaration of the UN outlines eight commitments to be reached by developing countries by 2015. At the UN World Summit on the Information in December 2003 in Geneva, all the world leaders agreed to mainstream ICT in the achievement of the MDGs. The only progressive ICT that has revolutionised the world and created the knowledge economy is the Internet and other related technologies like World Wide Web , (WWW). However, to enable developing countries leap frog from their current per-industrial economy to the research-based knowledge economy, broadband internet is required. Application of broadband Internet and other related technologies can lead to:

- improvement of the access to, efficiency, effectiveness and quality of education and healthcare;
- provision of opportunities for individuals, professionals and service providers to obtain information, communicate with professionals, deliver first-line support especially where distance is a critical factor and promote preventive medicine programmes;
- provision of employment especially in the Information Technology (IT) industry like telecommunications sector.

I particularly found VSAT broadband internet a useful tool in solving problems of gender inequality in education in rural Uganda (Lating, 2009). The purpose of the study was to show that the only technology that can pull Uganda out of under-development is the application of broadband in the transformation of its society. The study was done as part of my PhD studies in Makerere University.

1.7. Makerere University

Having started in 1922, Makerere University is the oldest university in Uganda with a fairly sound research infrastructure. This means that Makerere University can provide the required leadership as a research university in the country. The university has 87% of the lecturers with PhDs in all the 28 universities in Uganda. By the end of 2009, Makerere University had 36,000 students. This means that over 55% of the students in public universities study in Makerere University. Makerere is also highly rated in Africa; by December 2010 it was in the 10th position on the continent. It is so far the best university in East and Central Africa and it is the preferred choice by many students. Aspiring students normally rush to Makerere to seek admission since to them the university means everything: a solid education, prestige, career opportunities and a better future life. The demand for Makerere University degrees seems boundless, and in marketing terms, the brand is unquestionably a success.

To increase access to Higher Education in Uganda, public universities were allowed to start admitting privately sponsored students in 1991/1992 academic year. Privately sponsored students constitute more than 80% of the enrolment in Makerere University. In order to generate more money, thousands of fee-paying students are admitted every year. However, the Government has put a cap on fees for the university's privately sponsored students, meaning enrolment has grown faster than income. Private students are paying far less than it costs for their education. Consequently, private students are paying far less than it costs for their education. Makerere University, which was designed to have a maximum number of three thousand students, now has thirty six thousand students. Unfortunately, facilities and infrastructure have not been improved sufficiently to handle the large number of students.

In its 2008/9-2018/19 strategic plan, Makerere intends to focus on three areas:

- Shift from teacher-centred to learner-centred problem-based instruction or teaching;
- become a research-driven or research-led university so that it is relevant in the context of the contemporary knowledge economy. It plans to advance both basic and applied research.

• Shift from the current paradigm to knowledge transfer partnerships and networking in order to foster symbiotic relationships between the University and broad public and private sectors.

In Uganda, Makerere University has used donor funds to become the most successful university in East and Central Africa. Donors who helped Makerere's transition include Norad, the Pfizer Foundation and the Carnegie Corporation. But the key player today is the Swedish International Development Agency, Sida, with its Bilateral Collaborative Research Support programme worth 27 million USD (phase 2 from 2005-2009) and a further approximately 26 million USD (phase 3 from 2010-2014) . In 1999 Sida started working with Makerere University to help it reach a position where it could begin finding its own solution to Uganda's problems. SIDA funds core facilities needed to improve conditions for research, including laboratories, libraries and ICT infrastructure as well as PhD training for academic staff. It is only SIDA that supports the funding of core activities of Makerere University. This has helped to reintroduce the research culture in the University. Substantial capacity of the university to carry out research has been built. Initially, SIDA worked with individual researchers and faculties. But a bigger idea emerged: that the changes they were helping to bring about would endure only if the background context- the management, the money, the procurement, the infrastructure- were also transformed. The administrative reforms of the university are currently underway and the process is mainly supported by Sida.

Makerere University does mainly basic and applied research, which are strictly disciplinary, interdisciplinary or multidisciplinary. The result is that the University has accumulated a lot of unpublished theses and dissertations which depict research findings that are yet to be commercialised to make them useful to the society.

As a PhD student of Makerere University, I carried out transdisciplinary research, a type of research, which embraces theory and practice simultaneously. Hybrid e-learning was introduced in rural secondary schools and performance of science students drastically improved. The book depicts how the research co-evolved into triple helix processes and distributed knowledge production in the context of the application and implication of the research findings. One of the challenges of transdisciplinary research is that it is prone to conflicts. Challenges that were faced and how they were overcome are described in the book.

Chapter 2 – CO-EVOLUTION CONCEPTS AND METHODOLOGIES

2.1. What is Research?

The term 'Research' was derived from the Latin word 're-chercia', which literally means "to seek". Research means to search and search and search until solution is found to advance the course of development. It is the search for knowledge or any systematic investigation to establish facts. Research can also be taken to be a systematic investigation of a phenomenon. According to Toffler (1973) "The illiterate men of the 21st century will not be those who cannot read and write but those who cannot LEARN, UNLEARN and RELEARN". Toffler (ibid) had predicted the computer revolution, cable television, video recorders, cloning, and the rise of the knowledge economy. The author names the current information age as a 'Third Wave Civilization' and the industrial age as the 'Second Wave Civilization'.

Knowledge can mainly be generated or produced through research. There are two important characteristics of research:

- It is systematic because it follows certain steps that are logical and in order. The steps are: understanding the nature of the problem to be studied and identifying the related area of knowledge; reviewing literature to understand how others have approached or dealt with the problem; collecting data in an organized and controlled manner so as to arrive at valid decisions; analyzing data appropriate to the problem and drawing conclusions and making generalizations.
- It is based on scientific method of inquiry in reaching at conclusions.

Some authors take research to mean hunting for facts or truth about a given subject. Research, therefore, can be defined as 'an organized scientific investigation to solve problems, test hypotheses, develop or invent new products'. Some authors understand research as the process of looking for solutions to human problems through welldefined methods. It is a systematic way of learning to relearn and unlearn based on new insights derived from knowledge.

2.2. Other Sources of Knowledge

While scientific research generates knowledge for development, there are other ways of deriving knowledge which includes:

- Tenacity: what we know through basic beliefs of our daily lives
- Authority: what we know through what experts and authorities tell us
- Intuition: What we know through reasoning.

As a result of Africans' reliance on tenacity ("experience is the best teacher"), authority ("it is right because my father said so") and reasoning ("what one knows not does not kill, you can eat it"), Africans lag behind. The developed countries do scientific research, that is why their nations develop and progress. Research leads to development. Developing countries have not been doing much research, therefore their development is stunted. With more research, our development will boom.

While universities are being supported to carry out research for development, it is important to distinguish what type of research is relevant for transformation of the society.

2.3. Types of Research

Basic (fundamental or pure) research is driven by a scientist's curiosity or interest in a scientific question. The main motivation in basic research is to expand man's knowledge, not to create or invent something. There is no obvious commercial value to the discoveries that result from basic research. For example, basic science investigations probe for answers to questions such as: How did the universe begin? What are protons, neutrons, and electrons composed of? Most scientists believe that a basic, fundamental understanding of all branches of science is needed in order for progress to take place. In other words, basic research lays down the foundation for the applied science that follows. If basic science research, findings are 'used' in so far as they add to, change or refute elements of the total body of scientific knowledge. Research findings are 'used' in modifying scientific theory. The diffusion of the findings can lead directly to their utilization since the practice of science is scientific research.

Applied research is designed to solve practical problems of the modern world, rather than to acquire knowledge for knowledge's sake. The goal of the applied scientist is to improve the human condition. For example, applied researchers may investigate ways to improve agricultural crop production; to treat or cure a specific disease; to improve the energy efficiency of homes, offices, or modes of transportation. Some scientists feel

that the time has come for a shift in emphasis away from purely basic research and toward applied science. This trend, they feel, is necessitated by the problems resulting from global overpopulation, pollution, and the overuse of the earth's natural resources. Donors and many governments in developing countries ask whether the research findings will be socially useful or commercially viable before funding the study. Even in leading research universities, scientists are engaging more and more in market-oriented research since their research outputs are expected to address commercial needs. Applied research findings may also not lead to immediate utilization, no matter how well or how widely the results are disseminated.

Problems of Basic and Applied Research in Universities

Both basic and applied research that most universities in developing countries are involved in does not lead to easy and immediate utilization of the research findings. The research findings are not meant to cause change in society. Universities that focus on basic and applied research approaches emphasize publications as the main output of the research efforts. These are publications in books, peer-reviewed journals, non peer-reviewed journals, conference proceedings and manuscripts (unpublished academic work like dissertations and theses). The publications are meant for fellow likethinking academics and are in most cases directly irrelevant to the social changes that are required in the communities. Some of the universities arrange public defenses of PhD theses and dissertations. It is meant to make the public aware of the findings and possibly innovations that came out of the study and may be commercailised later in industry. Other universities arrange dissemination conferences and seminars for the same purpose-increase awareness of innovations that they may have realized through research.

The process of research utilization in institutions, organizations and businesses is not quite straightforward. There are many obstacles in this regard. First, the managers of the company must perceive the findings of the applied research as relevant to the organization. The researchers must also have sufficient weight or persuasive power to cause the manager to contemplate changing some aspects of the organizational structure, technology, tasks or staff. Lastly, the changes proposed must also carry with them the promise of reduced costs or improved performance or both. Organisations generally are resistant to change and there is a definite gap between intention to change as a result of research findings and the actual accomplishments. Resistance to change is, in fact, one of the principal causes of organizational failure.

Applied research was dominant in the 1940s as a means of supporting military industries during and after the Second World War. Thereafter, applied research was suitable for technology development for the product or industrial economy. In the researchbased knowledge economy, it is not very suitable.

Basic or applied research approaches can be disciplinary, interdisciplinary and multidisciplinary. Disciplinary research is done within a given science discipline like Chemistry, Mathematics, Physics, Biology, Botany, Zoology, technology and engineering. Realising that at some stage strictly disciplinary research was not suitable, interdisciplinary research was established with the main purpose of creating distinct disciplines like biotechnology, biochemistry, biostatistics, biomathematics, bio-entrepreneurship and so on. Multidisciplinary research is when disciplinary teams do research as part of a bigger research project. Unfortunately, all the results of disciplinary, interdisciplinary and multidisciplinary basic or applied research approaches do not lead to immediate utilization of research findings of the results in the social context for purposes of causing qualitative change in the well being of the society.

2.4. Innovation

Makerere University, a leading university in Uganda, focuses on basic and applied research. Graduate students do basic research and generate knowledge. Some carry out applied research and develop technologies that are demonstrated during project presentations. However, all these innovations rarely leave the gates of the university. To inform the public about such innovations, the university sometimes organizes dissemination conferences and public lectures. In 2001, it established a unit called Innovations at Makerere, I@MAK.

The Innovations at Makerere (I@MAK) was created to promote innovations in teaching and research aimed at making higher education more relevant to the needs of the country. Launched in February 2001, this initiative was set up to enable the central government, higher education institutions and local community councils in the decentralized Districts work together in building capacity to support the government's antipoverty decentralization policy. The project started implementing its activities in July 2002 with the main goal of contributing to overall improvement of service delivery in a decentralized district. Specifically, the project sought to strengthen the role of Makerere University and other partnering Higher Education Institutions in responding to human resource and research needs of decentralized service delivery to Districts. The project supported and initiated basic courses on decentralisation, which were operated by Uganda Management Institute. Start-up educational programmes were designed to equip graduates with the essential skills and attitudes needed for poverty alleviation work in the Districts. Support was also extended to pilot and facilitate field attachments for students of Makerere University in industry. Later, the project supported the development of field attachment policy and guidelines for Makerere University. Undergraduate and post graduate training of District local staff was done. Two model villages were set up in Maracha-Terego (formerly part of Arua District) and Rakai Districts as part of the outreach services of the University to communities. Resource centres were constructed in both model villages and furnished with facilities including solar power, internet services, furniture, water harvesting utilities and agricultural demonstration gardens. These centres act as demonstration sites for new and appropriate technologies from Makerere University and other Higher Education institutions. The I@MAK project also supported the establishment of a Resource Centre on decentralization located on the main campus of Makerere University. The Centre is in the Makerere Institute of Social Research. It was equipped with over 40 computers with internet access. The project also supported over 300 research projects aimed at getting possible solutions to challenges facing decentralized service delivery with the hope that the research findings would inform policy on decentralization of services. Realising the need to disseminate their research findings, the project started a journal called Makerere University Research Journal which was launched in July, 2006.

For five years, I@MAK trained District staff, provided extension services, conducted research and integrated findings into its programmes. Funding was made available for projects on an incremental basis, with a small grant given upon approval of a concept paper, more funds were given at the pilot stage and the largest grant was given for the full implementation of the project. The I@MAK project which was initially carried out solely at Makerere with funding from the Rockefeller Foundation was later expanded with additional funds from the World Bank to include other selected institutions of higher learning in Uganda.

I@MAK is a very important attempt by Makerere University to be relevant to the society. However, carrying out research in the context of the problem requires methods of Action Research to be used.

2.5. Mode 1 and Mode 2

According to Gibbons et al (1994) and later clarifications by Nowotny et al (2003), there are two processes of knowledge production: Mode 1 and Mode 2. Mode 1 is the traditional way of knowledge production. In this case, knowledge is produced within a strict disciplinary and primarily cognitive context. In this type of knowledge production or generation, the problems to be solved are set mainly by the academia and address the academic interests of the community. Mode 1 is highly hierarchical, linear and preserves its form. Quality control in Mode 1 is done by rigid blind peer reviews by disciplinary experts in the areas of research.

By contrast, Mode 2 knowledge production takes place in the context of the application and implication of the research findings. This makes Mode 2 transdisciplinary making it more socially accountable and reflexive. Mode 2 includes a wider, more temporary and heterogeneous, 'communities of practice', collaborating on solving a problem defined in a specific and localised context, Lave and Wenger (1991). The authors assert that the acquisition of knowledge is a social process and people participate at different levels. The community and participation in it are inseparable from the practice. 'Communities of Practice' include:

Situated Learning - Some theorists, for example Lave (1988) and later Brown, Collins, and Duguid (1989) and Anderson, Reder and Simon (1996), who ascribe to cognition and activity theory in particular, claim that learning is a function of the activity, context and culture, and is securely tied to the situation in which it occurs (i.e. learning is situated).

Informal and Co-located-The gradual acquisition of knowledge and skills learned from experts in the context of their everyday activities.

Group Knowledge-Knowledge is mediated through social interaction and collaboration in the group.

Legitimate Peripheral Participation -Novices move from peripheral to full participation as they gain legitimacy in the group.

There is a lot of debate regarding the two modes of knowledge production. However, it must be noted that knowledge production in the social context of the problem and implication of the results of the research findings is not possible without embracing Mode 2. Mode 1 method of knowledge production will be inadequate.

It should also be noted that Mode 2 has co-evolutionary effects and it demands participation in knowledge co-production by socially distributed co-actors. This means, effective communication is crucial in Mode 2. The modern advances in ICT, especially the use of broadband internet, have motivated the emergence of Mode 2 knowledge production.

2.6. Action Research

The issues of simultaneous organizational change or transformation and research findings utilization are tackled directly by 'action research'. Action research is concerned with organizational change. 'Action research aims to contribute to both the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework', (Rapoport, 1970). This means that action research should be participatory.

Action research is simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices and the situations in which the practices are carried out (Carr & Kemmis, 1986, p. 162)

Action Research involves a self-reflective, systematic and critical approach to enquiry by participants who are at the same time members of the research community. The aim is to identify problematic situations or issues considered by participants to be worthy of investigation in order to bring about critically informed changes in practice. Action research is underpinned by democratic principles in that the ownership of change is invested in those who conduct the research (Burns, cited in Cornwell, 1999)

Chapter 3 – THE PROCESS OF CO-EVOLUTION IN ARUA

3.1. Background

In 2001, a an undergraduate student at Makerere University, Faculty of Technology, Electrical Engineering Department did her fourth year project concerning sustainability of ICT Centres in rural Uganda. She found that ICT Centres with internet connectivity would be viable in two rural Districts in Uganda- Arua and Bushenyi. In her conclusion, she asserted that annual revenues from sales of internet services in those districts would almost be twice the start up costs for the ICT Centre.

3.1.1. Sida/SAREC Support

In May/June 1999 Sida/SAREC commissioned a study to assess the capacity and needs of the Faculties of Engineering in the then five Sida Partner Universities in Southern and Eastern Africa. The Universities covered were:

- Zimbabwe- University of Zimbabwe; National University of Science and Technology;
- Mozambique- Universidade Eduardo Mondlane (UEM)
- Uganda- Makerere University (MAK)
- Tanzania-University of Dar es Salaam (UDSM)

The objective of the study was to assess the following:

• The existing capacity of the Faculties of Engineering and the quality and relevance of the engineering programmes;

- The capacities of the Faculties of Engineering for undertaking Research and Development (R&D)
- The problems and constraints involved in the management of Research and Development (R&D) and its links to the productive sectors of the economy; and
- The opportunities for regional co-operation.

The important findings which emerged were that the engineering faculties:

- had a number of common needs;
- had a number of different needs;
- lacked strategic plans encompassing their policy, planning and management frameworks to improve quality, relevance and effectiveness of teaching and learning as well as R&D;
- had weak ICT infrastructure;
- had inadequate facilities and had weak linkages between University and Industry.

The findings formed the basis for a series of recommendations to the Universities and to Sida/SAREC. It was subsequently recommended that Sida/SAREC supports the Faculties at both institutional and regional levels. Under the auspices of the Sida/ SAREC support, the Faculty of Technology, Makerere University, in collaboration with other Swedish universities and institutes, commenced a first collaboration effort from September 2000 to the end of 2001.

The aims of the specific Sida/SAREC research cooperation program with Faculty of Technology, Makerere University, were to:

- a. Promote capacity building of PhD supervision at Makerere University with PhD degrees as by-products.
- b. Develop technologies for sustainable development within the Lake Victoria and other water resources in Uganda
- c. Develop collaboration between researchers at other universities in East Africa (Makerere University in Uganda, Dar es Salaam University in Tanzania and Eduardo Mondlane University in Mozambique)

The preliminary phase (from 2000 to end of 2001) was used for partners to learn to know each other, to attend a common Workshop in Kampala, Uganda, and to work out an elaborate application for Phase I support of the program. The Sida/SAREC funded research cooperation program with Faculty of Technology is done under the theme 'Sustainable Technological Development in the Lake Victoria Region'. The Faculty of Technology identified six sub-programs in the following fields: Highway Engineering, Architecture, Ceramic Materials, Water Quality Management and Pollution Control, Biomass Fuel for Rural Development and Solar PV for Rural Electrification

The first formal phase of the program was from 2002 to the end of 2004. In 2004, Phase I was supplemented by an 'Extended Program' in which ICT/GIS sub-programme was introduced..The Extended Phase I of the Sida/SAREC support lasted until the end of June 2004. Phase II of the Sida/SAREC cooperation support lasted from July 2005 to June 2009. Phase II was extended from July 2009 to December 2009 to allow Makerere University carry on with continuing research activities while developing a Phase III support for the period 2010 to 2014.

3.1.2. ICT/GIS Research Project in Engineering Mathematics Department

Within the Faculty of Technology, all the sub-programs are hosted in the departments where they are best suited to be. The ICT/GIS sub-program is located in the Sub-Department of Engineering Mathematics.

The main research area objective of the ICT/GIS research sub-program is to create and increase research capacity in establishing optimum ICT requirements and sustainable ICT configuration for sustainable rural development.

The specific objectives are to:

- Generate data for the creation of sustainable rural networking programme of ICT for dissemination to Internet Service Providers (ISPs), mobile telephone service providers and other stakeholders interested in rural ICT implementation and also generate further interest in rural ICT for other stakeholders
- Address internet connectivity and networking issues at the District level with low level connections to sub-counties (the last mile)
- Address issues related to capacity building for local stakeholders and rural content development with an important component for raising ICT and GIS awareness at the District decision-making levels
- Sensitize District decision-makers and administrators on the central role ICT and GIS in the management of resources and administration of institutions
- Research on the optimum means for the creation of sustainable capacity in ICT skills at the District and sub-county levels and rural learning institutions
- Foster gender balance and positive discrimination towards the rural girl-child education by the use of ICT
- Research on the optimum methods of applying GIS use in rural areas.

3.2. Research Location - Arua District

The ICT/GIS research team decided to follow up on the findings of the Makerere electrical engineering student that ICT Centres would be viable in the rural Ugandan Districts of Arua and Bushenyi. Of the two Districts, Arua was, and still is, the most disadvantaged. We decided to set up the ICT/GIS Research Centre there. The Research Centre was later used as part of my PhD research activities by introducing Hybrid E-Learning in secondary schools in Arua. Arua District is shown in the Fig.3.1.


Figure 3.1 Map of Uganda showing the location of Arua District

3.2.1. First Field Visit to Arua

The first visit of the ICT/GIS Research team to Arua was from 29th March, 2004 for one week. During the visit, the team wanted to sensitize the District executives and administrators on the benefits of embracing ICT in their activities. We met the following groups of people:

- The Resident District Commissioner, RDC- a representative of the President of Uganda in the District.
- Deputy Chief Administrative Officer, CAO together with his subordinate staff member, the District Statistician. The substantive CAO was under interdiction from office that time. CAOs are the accounting officers in all the Districts in Uganda. They are appointed by the Central Government. The Constitution of Uganda was amended to make sure that the CAOs were not appointed by the Local Governments. Many critics say it deprives Local Councils of the autonomy they need to be independent under the Decentralisation policy.
- The Local Council 5 Chairman (usually abbreviated as LC5). The LC5 chairman had some of his Council members attending the meeting. He was accompanied by the District Secretary for Production and Marketing, the District Secretary for Technical Services, the District Secretary for Education and Sports, the District Vice Chairperson (Vice to LC5) and the District Speaker of Parliament. Under Decentralisation, every District in Uganda has its on Local Government.
- Eight head teachers of some secondary schools in Arua District. Muni Girls sent the Deputy Head teacher to represent the Head mistress of the school. The District Education Officer attended the meeting together with the Director of Muni National Teacher's College, NTC. The Director has since retired from public service and was replaced by another one.
- Seventeen business executives. Most notable in this meeting was the Chairman of the District Chamber of Commerce and Industry.
- The Medical superintendent of Kuluva Hospital. This is a private hospital which is supported by the German Government
- The Management Advisor of SNV also met the research team. SNV is a non-profit, international development organisation, established in the Netherlands in 1965.

We received a very warm welcome to the District by the local leaders. All of them pledged full support for the entire period Makerere University would be doing research in the District. Generally, most of the people wanted internet services, websites to be developed for them, improvement in administrative efficiency through use of ICTs, improved planning by using GIS, improvement in basic ICT skills and working with e-mails, improvement in performance of secondary school students especially in science and mathematics subjects and farmers wanted accurate information on prices of products.

3.2.2. Second Field Visit to Arua

Some members of the ICT/GIS Research team went back to Arua for ten days with effect from 9th April, 2005. During that visit, one of the objectives the team wanted to achieve was to identify a building to be rented for purposes of setting up the ICT/GIS Research Centre with internet connectivity.

During the second visit, we met the following District officials: the Resident District Commissioner; the LC5 Vice Chairman together with the District Information Officer and the Secretary for Production and Marketing; the District Statistician; the District Education Officer together with his Deputy District Inspector of Schools and the Chairman, District Chamber of Commerce and Industry who was also a part time lecturer in Muni National Teachers's College, NTC. He also owned a company which was carrying out some computer literacy training in Arua town.

The Vice Chairman welcomed us to the District and offered total support for the research we would be doing in Arua. He said that what we were doing was a sign that Makerere University was already changing from its former position as an Ivory Tower to an institution that was interested in solving problems experienced by disadvantaged communities in rural areas. The team also held discussions with the District Statistician and the District Education Officer, DEO.

Towards the end of the second visit, the team inspected a private residential house that was being offered for renting. The house is located on Plot 6 Ndebua Road. The Plot is of approximate size 53×47 meters. The house was to be completed within 2 months, see fig.3.2. Plastering, painting and installation of utilities like water and electricity needed to be done. The perimeter fence also required upgrading.



Figure: 3.2. Part of the incomplete residential house that was being offered for rent.

The Arua District leadership also proposed to allow us to use the former Chief Magistrate's Court Buildings which were temporarily occupied by the Arua Golf Club. The buildings offered are shown in fig. 3.3 The District leaders felt that they should also offer some contribution towards the Research Project in their District. Makerere University would not pay rent for the buildings. However, renovation, repairs and maintenance of the buildings so as to be suitable for our purposes, would be done by Makerere University. The buildings needed to be burglar proofed and the perimeter fence had to be upgraded. The halls of the bigger building needed partitioning so as to create training rooms and offices suitable for carrying out the objectives of the study.

That time, the Golf Club building was still under renovation. The golfers were expected to shift by June/July of 2005.



Figure: 3.3 Former Chief Magistrates' Court building that the District proposes to offer as a possible site for the ICT/GIS Research Centre

3.3. Setting up the ICT/GIS Research Centre

The offer by Arua District local Government to give us two buildings free for use as our ICT/GIS Research Centre was received with a lot of interest. Rather than rent one incomplete residential building, the research team decided to collaborate with the District Local Government.

We sent a formal letter of application to CAO requesting that the District Local Council should allow us set up the ICT/GIS Research Centre in the former Chief Magistrate's Court buildings in Arua town. The letter dated 26th April, 2005 was jointly signed by the coordinator of the ICT7GIS sub-program and the then Acting Head of the Sub-Department of Engineering Mathematics, Faculty of Technology, Makerere University.

The positive reply to the application is contained in the letter written for CAO to the Coordinator of the ICT/GIS Research Project on 13th May, 2005. The letter reads in

part as 'I am pleased to inform you that the District Leadership has no objection to your request to access the former offices of the Magistrate for establishment of the ICT for Sustainable Rural Development (ICTSRD) Research Project. You can now approach the District for discussion of the formalities involved in the use of the premises'.

Before we wrote a letter thanking the District for this offer, the Acting CAO sent another letter from the District on 20th June, 2005. The letter reads '... Whereas the District leadership has no objection to your request to utilize the former court premises of the District Local Government for the project, it will be advisable and necessary for you to make modest improvements to enhance security of the premises and any other innovations that will make the place more functional ie. burglar proofing.

The District is waiting for you to finally conclude the necessary paper work, for the records.

Could you kindly let us know when you will be available to finalise the formalities'.

The tone of this second letter from the District shows how they were impatient with us in setting up the ICT/GIS Research Centre. We had to increase the pace of our work.

At this point, I took over as the Lead Researcher and started implementing all aspects of the ICT for Sustainable Rural Development (ICTSRD) Research Project. We started the usually slow process of procurement of the ICT Research equipment. Items procured included the following:

- Seven desk top computers, one canon photocopier model 6512, and hp 1320 laser jet printer and one UPS 1 KVA APC from Ms Cyber Base Ltd at 13,430,000 UGX (6,715 USD)
- One VSAT equipment together with payment for site survey, installation and annual subscription including a 17% VAT at 10,822.5 USD from Ms AFSAT Communications Uganda Ltd. Note that later Uganda Government increased VAT rate to 18%.
- One IBM server from Ms International Business Solutions Ltd at 4,572.64 USD
- 15 additional IBM desk top computers with DVD/CD-ROM drives from Ms International Business Solutions Ltd at 10,125 USD
- 20 UPS from Ms International Business Solutions Ltd at 4,050.94 USD
- Cabling and Networking of the computers for purposes of connecting to internet was contracted to Ms Cyber Base Ltd at 5,475 USD
- Two signposts for the ICT/GIS Research Centre were fabricated by Consult Arts Ltd in July 2005 at approximately 383 USD

All these research equipment and items procured were transported to Arua during the numerous field visits between June and August 2005. I was using the Sida/SAREC research pick up vehicle which is small and can only carry a few items during each trip to Arua. The former Chief Magistrate's Court buildings that were offered to us were still being occupied by the West Nile Golf Course. We were keeping the items in the stores of the CAO. The Golf Course building of the golfers was still being constructed and legal wrangles emerged between the clients and the contractor. This caused a delay and the contractor promised that the building would only be ready by January 2006.

I made it known to the District officials that we could not wait until January 2006. We had already delivered all the equipment for the research Centre and they were being kept in the stores of the District Acting Chief Administrative Officer. Consequently, I met the District Vice Chairman, who is also the Chairman of the West Nile Golf Club. We discussed the issue at length in the presence of the District Information Officer. We agreed that the Faculty of Technology could immediately occupy the smaller building of the court premises and start the implementation of the Project. Before we left Arua to come back to Kampala on 18th August 2005, the smaller building had already been vacated and handed over to us.

We inspected the small building with the District Executive Engineer. The inspection and costing of the repairs necessary were done by Faculty of Technology civil engineering students, who were carring out their industrial training in Arua District. They did a good job though we had to revise their costs upwards to cater for better burglar proofing and provision of socket rings (trunking). We had to do the repairs of the small building urgently and install the research equipment. It would not make sense if we continued to lose any more time.

I went back to Arua for one week again, from Saturday 3rd to Sunday 11th September 2005. On Sunday 4th September, 2005 money for the repairs of the small building was given to the District Executive Engineer. Repairs were started on Monday and were expected to be completed on Saturday, 10th September, 2005. Unfortunately, due to heavy rains during the week, those repairs were not completed. The completion date was revised to Saturday, 17/9/2005.

While repairs were going on, the District Information Officer, one of those extremely excited by the Project, was running announcements on local FM radio stations that the ICT/GIS Research Centre was open. People started coming to the Centre thinking that they would access internet services. But we were not ready yet. Managing the excitement caused a lot of problems for me. People were disappointed when they learnt that I returned to Kampala since the repairs were not completed.

After being informed by the District Executive Engineer that the renovation and repairs of the small building were completed, I returned to Arua from Friday 4th November 2005 for four days. The following activities were accomplished:

- Together with experts from Ms Cyberbase Limited, 10 computers were installed and networked after completing cabling of the smaller building.
- During this trip, the process of renovating and repairing the main building was started even if it was still being used by the Golfers. Again, the District Executive Engineer, supervised the exercise. All the 14 steel windows of size 1.5m x 1.2m together with the 15 steel vents of size 675mm x 360mm were burglar proofed. Funds that time were inadequate to burglar proof the remaining three doors.

In December, 2005 I returned to Arua with the ISP, AFSAT, to install the satellite disk and connect VSAT Internet to the Centre. Fig. 3.4 shows the installed VSAT disk.



Figure 3.4. Installing VSAT disc in the Faculty of Technology ICT Research Station in Arua. The renovated small building is shown in the background.

AFSAT finally hooked the Centre to the satellite link on 16th December 2005. This was a nice Christmas gift for the people of the region. The Service Level Agreement states that the project pays 450 USD monthly for usage of 3,072 MB volume of data. Additionally we pay 350 USD as annual fees. When 18% VAT is applied, the Centre pays 6,785 USD annually for the VSAT connectivity.

At the beginning of 2006, we continued with the renovation and repairs of the main building that was still being occupied by the Golf Course members. The contractor again failed to hand over the Golf Course building to the clients by January 2006. Meanwhile, I continued to purchase more equipment and furniture and transporting them to Arua. For example, I visited the Centre from 27th to 31st March, 2006. Eight monitors were delivered in the stores of the Chief Administrative Officer since the main building was not yet free. During my trip to Arua in May 2006, I again delivered twenty plastic chairs and an IBM server in the stores of the CAO.

At a meeting with the District on 15th May 2006, a Management Board for the Centre was set up consisting of:

- The coordinator of the sub-program, Makerere University, Chairman
- The Arua District Information Officer, Secretary to Management Board
- Eng Dr Peter Okidi-Lating, the ICT Researcher, Member

- His Lordship, the Mayor of Arua Municipality, Member. He was also the Chairman of the District Chamber of Commerce and Industry.
- District Council Representative for Gender, Labour and Social Affairs. This Member was to be nominated by the District Council and had to be a lady.
- The Head Teacher of Muni Girls Secondary School, Member

At the same meeting it was agreed that the main building was to be partitioned into three classrooms for:

- Basic ICT Skills training
- Intermediate ICT training and
- Advanced ICT training.

More specialized training was to be done in the smaller building where ten computers were connected to the VSAT Internet. The District Engineer was given funds to complete the repairs of the building, partition it into the three classrooms, burglar proof all windows and vents and screed the floor. In the final analysis, renovations, repairs and partitioning of both buildings amounted to 12,000 USD.

It was agreed that the staff on the ground should be recruited from among the local community and should consist of: one systems administrator who would see the day to day running of the Centre; four trainers (for each of the classes); one support staff who would work as a receptionist/cleaner and two security guards.

After this meeting a Systems Administrator and a Receptionist/Secretary were recruited for the Centre. Two armed guards were deployed at the Centre by the District Council for purposes of providing reliable security to the research equipment and staff at the Centre.

The Centre was finally opened for public use on 15th June, 2006. ICT coordinators from the nearby secondary schools (Muni, Ediofe, Logiri and Mvara) were identified and trained as trainers. Ten second year Telecommunications Engineering students of Makerere University were used in this exercise as part of their Industrial Training during the Recess Semester. Within two months, up to 1,253 people were trained in Basic ICT skills, Internet use and working with e-mails. Those trained included District heads of Departments, secondary school teachers together with their students and the general public. Working people were coming for training from 17:00 to 20:00 hours. During school holidays, Ordinary level secondary school students were trained in the afternoons from 14:00 to 17:00 hours. Advanced level secondary school students were trained in the mornings from 8:00 am to midday.

The Centre started getting trainees from West Nile Districts of Uganda, South Sudan and Democratic Republic of Congo. District leaders from other Districts in West Nile (Koboko, Yumbe, Nebi, Adjumani, Moyo and later Maracha/Terego) were coming for ICT training on week ends- Saturdays and Sundays. The research project in Arua coevolved into a triple helix process with the following stakeholders:

- Makerere University, Faculty of Technology for research
- The Local Business Community by using research facilities for improving their businesses. The following private businesses use the facilities at the Centre for a small fee: West Nile Rural Electrification Company (WENRECo); Uganda Breweries; Private Sector Initiative (PSI) Uganda; Sumandura Construction Works; Boniface Television Networks; Nile FM radio station; Arua One FM radio station; Copcoot Uganda; West Nile Distilleries; Heritage Gardens- hotels business; Multitech Uganda- an ICT training business; Kuluva Hospital; and Marie Stopes Uganda a reproductive health provider.
- Arua District Local Government provided premises with a view that the services of the Centre would benefit communities, public institutions and the District leadership. Fig 3.5 shows the toll depicting the triple helix collaboration with Arua District Local Government



Figure:.3.5 One of the sign posts at the Arua ICT/GIS Research Centre

 Other Triple Helix Stakeholders- Besides the three main stakeholders mentioned above, the project has also involved other stakeholders and interested partners and individuals. They are International Non-Governmental Organisations (NGOs) and Community Based Organisations (CBOs) like Netherlands Development Organisation (SNV) Uganda; United Nations High Commission for Refugees; DED /(Community Based Organisation); Cream Uganda (Community Based Organization); PAD (Community Based Organization); PRAFOD (Community Based Organization); CAFECC ((A Sudanese Community Based Organization); World Vision Uganda; WENDWOA (A women organization helping widows and helpless children); Right To Play; NSEA / Needs Service Education Agency • Others Stakeholders are researchers; students doing online courses in and outside Uganda; visitors to Arua; traveling Agents; students from schools outside Arua District mostly during holidays; community workers; indigenous people who mostly use the Internet for communication with their relatives and friends in and outside Uganda.

Chapter 4 – MODE 2 KNOWLEDGE PRODUCTION

4.1. Situational Analysis of the Study Environment of Rural Schools

By 2004, Arua was one of the rural Districts in Uganda that had not sent a female student on merit for engineering education in Makerere University, Faculty of Technology. We decided do implement the hybrid e-learning project in that District.

During field visits to Arua, it was found that in 2006 Arua District had 47 secondary schools of which 25 were Government-aided and the remaining 22 were private. There were only six Government grant-aided secondary schools that had both Ordinary and Advanced Levels of secondary education. Of these, only two were advanced-level girls' secondary schools: Muni Girls' Secondary School and St. Mary's Ediofe Girls (hereafter referred to as Muni and Ediofe respectively).

My first visit to the two schools was during a field trip to Arua from Saturday 9th to Wednesday, 13th April 2005. In Muni, I met the Deputy Headmaster. The Head teacher was not in the school. I noticed that the school had started the construction of a storied classroom project shown in Fig. 4.1 The construction of the building was completed and is now being used by students.



Figure 4.1 A new classroom block under construction in Muni Girls Senior Secondary School, one of the participating girls' schools in the Research Project

Just like Muni, Ediofe is a boarding girls' school that was headed by a Catholic nun. I first visited the school in April 2005. That time, I also met some science teachers and the Deputy Headteacher who was also a qualified teacher of Advanced level Physics. Fig. 4.2 shows a group photograph we took, when I first visited the school.



Figure 4.2 Some members of the ICT/GIS Research Team with the Headteacher of Ediofe Girls and her Deputy

I left Kampala again for Arua on Sunday 14th August, 2005. During this trip I again visited Muni and Ediofe and continued to learn the difficult contexts under which they operated. I was in Muni on Monday, 15th August 2005. I met the Head teacher together with her Deputy and an A-level Physics teacher who doubled as the head of science in the school, head of Physics Department and a Physics teacher. I visited Ediofe on Wednesday, 17th August, 2005. The Headmistress had gone to Kampala and we were received by the Deputy Headmaster, who is a teacher of A-level Physics and a UNEB examiner. I also met a teacher who teaches Physics and Mathematics at A-level though that time he was a Diploma holder. He has since upgraded to a degree holder and is now able to teach at that level of education though with some difficulty. The teachers with Diploma are not licensed to teach at advanced secondary level. Those two were the only teachers for both Physics and Mathematics in the whole school that time.

We visited both Muni and Ediofe a number of times during subsequent field trips to Arua District. The aim of the field trips was to get an insight about science education in a typical rural District of Uganda. The schools were found to be lacking science infrastructure and facilities that could be used by students to make them pass national examinations. Both schools (Muni and Ediofe) are categorized as rural girls' boarding schools.

The school foundation body for Muni is the protestant church, while Ediofe is of catholic foundation. Foundation bodies in Uganda are stakeholders in the running of the schools.

Both schools were established in 1983 by Government of Uganda. They were established originally in primary schools that were in the areas where the schools were but later structures for secondary level were constructed and they shifted to their current sites.

In 2005, Ediofe had a total enrolment of 580 girls, of which only 107 were in advanced secondary level (Senior Five and Senior Six – abbreviated as S5 and S6 respectively). By 2007, Ediofe had increased enrolment to 710 students. Shortage of classrooms and dormitories limit admission of female students to Ediofe. The enrolment in Muni had risen to about 800 students at the beginning of 2008.

In Uganda students are admitted into advanced secondary level based on the total aggregate on best done eight subjects at Ordinary Level national examinations that are centrally set and administered by the Uganda National Examinations Board, UNEB. It is an autonomous body under the Ugandan Ministry of Education and Sports. Muni and Ediofe admit averagely performing students. Cut-off points for both schools are low since they admit mainly rural poor students. They do not enrol the best performing students in the country. Good performing students are reluctant to study in rural schools.

In 2006, both schools did not have the current curriculum, examination syllabus, teaching syllabus and schemes of work for advanced-level secondary Physics and Mathematics subjects. Teachers were found without teaching guides for both subjects. UNEB publishes examination syllabi for schools to purchase. Both schools did not have the then current UNEB examination syllabus (UNEB, 2003). The schools considered them expansive to buy, yet a copy for A-Level subjects was being sold at less than 5 USD.

The financial status of both schools was not good. Muni's actual expenditures were 168,423 USD in 2004, 234,190 USD in 2005 and 301,380 USD in 2006. These were expenditures for running the school with approximately 800 female students for the whole year. This translates to spending less than 1 USD a day on a student; hence its status as a poor school (if we maintain that poverty is measured in dollar terms). The biggest contributions towards the school budget were revenues collected by charging various fees to be paid by the parents and guardians of the students. But the parents and guardians were generally very poor with an average annual GDP per capita of less than 300 USD, well below the national average.

Both schools had no advanced level science laboratories where experiments could be done. According to UNEB, 40.8% of secondary schools in Uganda have no functional science laboratories. Muni and Ediofe belong to this category of schools. However, both schools had junior, non-functional O-Level laboratories with enough furniture but with poor fittings, broken water systems and no gas facilities. For example, the laboratories in Muni were found to have no running water. Laboratory technicians and laboratory assistants in both schools were not qualified. The junior O-Level laboratory block of Ediofe was built and partially equipped using funds from the United Nations High Commission for Refugees, UNHCR. The laboratory block is depicted in fig. 4.3. This grant amounted to about 50,000 USD. However, the funds were not enough to install facilities like electricity in the laboratory block. Ediofe re-paid the UNHCR debt by admitting every year Sudanese refugees for free study in the school. It drastically affected the cash flow situation of the school for many years. Both schools were using their science laboratories as ordinary classrooms since they hardly conduct any practical lessons.



Figure 4.3: The unfinished laboratory block of Ediofe Girls SS built using UNHCR funds

Rural schools perceived that science equipment, chemicals and consumables were expensive. Very few practical lessons were arranged for the students since the schools were reluctant to purchase the required materials. Examination syllabus requires that every week a student must do one practical lesson in each of the core science subjects: Physics, Biology and Chemistry. Muni in 2006 poorly organised only three practical lessons for the female students in S5. To do practicals, rural schools either borrow or share such equipment from other schools. However, for UNEB examinations at the end of the year, the schools are obliged to purchase the required chemicals and equipment. But in most cases, the students see some apparatus, equipment and chemicals for the first time in final examination rooms. They do not have the opportunity to practice the use of some equipment and instruments early during normal lessons. In one case that I witnessed, a student was measuring temperature of a chemical reaction using a meter rule!

The laboratories in both schools were found with enough equipment for O-Level practical work. These are items purchased for previous UNEB examinations. However, the equipment lacked adequate maintenance and repair. Some measuring instruments like venire callipers, micrometre screw gauges, voltmeters and ammeters were found to be out of calibration, some did not work, others were broken. They were also poorly kept or stored.

Both schools did not have laboratory manuals for science subjects. Yet manuals help teachers, laboratory technicians and students to define goals and procedures for laboratory activities.

Both schools had acquired used, inferior computers without multimedia capabilities from the National Curriculum Development Centre, NCDC. There were ten such computers in Muni while Ediofe had 15. It is of concern when a Government autonomous body gets involved in supplying obsolete ICT equipment to schools.

Muni had a computer laboratory but Ediofe did not have one. The computers of Ediofe were installed in the small store in the library with space just enough for five computers. However, both schools had no laboratory computer technicians. There was no Internet in any of the schools. Almost all teachers and their students were found to be computer illiterate.

There were libraries in both schools with enough furniture but few relevant text books. The library in Muni was built with assistance of the Blue Caravan, a Swedish students' association. UNIDAS, a Spanish organization, helped Ediofe and provided funds for the construction of their library. Neither the schools nor the students could afford to purchase the recommended text books in enough quantities. Both libraries had no qualified librarians. In Muni, an O-Level teacher had taken over the role of a librarian. Ediofe assigned one of the support staff to act as a librarian.

The schools had reliable electricity supply from a local power generation and distribution company, the West Nile Rural Electrification Company, WENRECo. It was supplying thermal electricity using black oil for 18 hours a day, from 6:00 am to 24:00 pm. However, thermal electricity is three times more expensive than hydro electricity.

Furthermore, WENRECo is a monopoly in West Nile. Their public relations with clients were very poor and the level of service needed improvement. Its services later collapsed after the upheavals in Kenya in 2007 when General Elections were disputed and the country resorted to violence. WENRECo failed to get oil for their generators from Kenya and the company almost went bankrupt. Now it is limping with very unreliable electricity supply, sometimes for only two hours a day.

Muni now has enough classrooms after completing their three-storied classroom block with the help of their Parents and Teachers' Association, PTA. Ediofe had shortage of classrooms. The A-Level science students were using the O-Level laboratories as classrooms. To build a five-classroom block requires about one billion million Uganda shillings (approximately 400,000 USD). The schools could not afford such a capital expenditure and Government financial situation was also no helpful.

Dormitories were congested because of increasing student numbers. The dormitories in Ediofe were found to be in appalling state. They were dilapidated with walls cracked to the foundation and their roofs were leaking. When it was raining, there was a lot of fear that the buildings might collapse on the students. With the help of Japanese Government, a new dormitory block was constructed and handed over to the school in July 2008.

Both schools were getting water supply from the National Water and Sewerage Corporation, a Government parastatal body. The level of sanitation was relatively good.

Edife had a newly constructed main hall built with support from friends of the Headmistress from the United States of America. It is where the students hold their assemblies. Ediofe did not have a dining hall. Muni had no main hall but it was constructing a multi-purpose building, which will have a dining hall, assembly hall and an examination hall. The construction of this complex was being funded by the Government under the Northern Uganda Action Fund, NUSAF. This fund was set up by the Government to rehabilitate war-ravaged Districts of Northern Uganda. The Students were getting food from the kitchen and going to eat from their dormitories.

There was an acute shortage of residential houses for teachers. Muni had 41 teachers and only 8 staff houses. Ediofe had only 9 of the 48 teachers housed in the school. Teachers who were not housed in the school were paid allowances to enable them rent houses in town. This limited the availability of teachers on the campus. They were not readily available for the students to consult. Moreover, the rent money was not enough to let them acquire a decent accommodation. The few teacher's houses were in very bad state of repair. Most of the teacher's houses needed major repairs.

There was only one qualified and experienced teacher of Physics in Ediofe. He was possessing a B.Sc (Physics) plus a Post Graduate Diploma in Education, PGDE. The rest of the teachers for Physics and Mathematics were not qualified to teach at A-Level. The qualified and experienced Physics teacher was, unfortunately, the Deputy Head teacher of the school. This deployment limited his classroom time. But it was found necessary to deal with him during the hybrid e-learning project. While both schools had many teachers, science teachers were few. In the organization of science teaching in the schools, it was common to get that the head of science in the school, the head of a particular science subject and the science subject teacher being the same unqualified teacher. The few science teachers were overstretched. They were given many periods to teach in both O and A levels. The MOES recommends that a teacher should teach 22 periods a week. In Muni and Ediofe science teachers were taking 32 periods a week. Salaries of teachers were extremely low. A university graduate qualified teacher was paid a gross salary of between 269 - 343 USD per month (before taxes). Qualified teachers who hold diplomas in education were paid a gross of 235 USD per month. In a family where the woman is expected to have 6.7 births, this also amounts to spending less than 1 USD a day on every member of the family. This means most teachers live below the poverty line. This is another case of disguised unemployment. The meagre salaries create a powerful incentive for teachers to teach in more schools so that they can get more income. To rely on one salary will not make ends meet. The effect is felt by the students who are not taught. Even if the school assigns a teacher to teach 32 periods a week, he/she will dodge most of the lessons since they teach in many schools.

Lack of promotion in the teaching profession was also another de-motivating factor. Teachers generally have limited prospects for promotion in Uganda. It is common to get newly recruited teachers who get the same salary with other teachers having vast experience in the field. The MOES had not created a structure where teachers can be promoted. Many class room teachers retire from public service after 40 years of service without promotion. This de-motivates teachers. The teaching profession is considered a demeaning job. Most people go into teacher training as a last resort for fear of dropping out of the school system. These institutions admit students who have failed to progress in the field of academics. They did not like teaching as a profession in the first place. They eventually become teachers of subjects that they did not score well in, at A-Level.

Coverage of the content by teachers was found to be shallow, a reflection that the teachers were not qualified. The subject matter was not covered to the depth and breadth required by the syllabus. The teachers did not teach some of the topics they were not competent in. This led to a low level of syllabus coverage in both schools. In Muni, sometimes only one third of the syllabus was covered.

Muni and Ediofe did not have strong Parents and Teachers Associations (PTAs). PTAs are associations between teachers and parents. The main essence of creating PTAs in Ugandan schools was to try and bridge the funding gap between what the school needs and what the Government provides. Parents, who are interested in the education of their children, formed the PTAs. The parents agree to pay additional money to the schools to improve the welfare of teachers and students, build laboratories, libraries and classrooms, improve water and sanitation situation of the schools. PTAs are only effective in the elite schools in urban areas where there are many rich parents and guardians. That is why tuition/fees in such schools are two or three times higher than in rural schools. Rural schools imitated advantaged schools in urban areas and formed

PTAs that are not effective. For comparison, Ediofe student was paying 117.5 USD per term while a similar student in Namagunga (also a Government aided school) was paying 338.4 USD) and Seeta High (private school) was paying 381 USD per term. Parents of Ediofe, just like those of Muni, had difficulties in paying the comparatively low fees the rural schools charged. In some cases the students complete one cycle of education (A-level) without completing payment of fees for the previous cycle (O-level). Teachers in schools where PTAs are strong are paid well and are more committed to their jobs. Laboratories and libraries are functional.

Schools are governed by the Board of Governors. For every school, this is the policy making body. The board has a chairman, and the school head teacher is the secretary to the board. The Government has a representative on that board. In schools like Ediofe and Muni that are founded on religious principles, key positions on the board are offered to practicing Christians. The church normally takes the position of the chairperson of the board and he/she takes part in the appointment of the headmistress. That is why Ediofe was led by a catholic nun and Muni's headmistress is a born-again Christian. Both schools are used by their respective foundation bodies for training students in Christian values and morals. Christian evangelization is done through the schools. However, it was noted that the school leadership of Muni was based on fear and lack of trust among teachers, students and the administration. Corporal punishment was practiced in the school despite the Government ban of the practice. Students were caned and beaten. This had a negative impact by lowering the selfesteem of the students. It is regarded as violence against children. Indefinite suspensions of the students were frequent in Muni. Students of Muni regarded themselves as being under constant environment of fear. Some teachers, especially in Muni, were openly abusing alcohol while others had very poor attendance records. This was because some of them teach in many schools. Such teachers were not effective in any of the schools where they were teaching. On the contrary, the leadership of Ediofe was participatory; teamwork spirit was exhibited at all levels.

Feeding and nutrition in both schools was found to be fairly satisfactory despite the rising costs of maintaining students in the schools. Like in most rural schools, beans and maize meal remain the most dominant menu in Muni and Ediofe. However, fruits and vegetables were not served in adequate quantities to the students. It is generally believed that good feeding of a student can facilitate better performance in school.

Both schools did not have associations of old girls. Most former old girls do not progress to pursue higher qualifications and get good and respectable jobs in public and private sectors. The schools were unable to get role models from their own former students. Advantaged urban schools that are mainly concentrated in the Central Region of Uganda have very strong associations of old students. Such associations of old students form very strong lobby and advocacy groups for their former schools. They have a stabilizing effect on the schools by checking administrative incompetence while at the same time inspire the continuing students. They also arrange additional fundraising for their former schools for projects that the schools may be undertaking. All the students were found to be from very poor backgrounds. Many of the students were found to be orphans, and a few of them were total orphans (both parents have died). The parents and guardians had difficulties in providing enough personal effects for their daughters. Just like the schools, the parents were unable to purchase personal textbooks and other scholastic materials for their children. In a number of cases, the students admit that their parents and guardians could not provide personal effects for them. The situation was made worse because some parents thought the girls were big enough to get married and stop bothering them. In a number of cases the students entered into love relationships with businessmen and employed men who provided personal requirements for them. In the process, some female students got pregnant and dropped out of school. One girl from Ediofe and six girls from Muni who were in the project were already pregnant before the two year project ended. They did their national examinations when they were already pregnant.

It was common to find that a number of students were reporting two weeks late after the official opening of the school term. Parents and guardians would look for some little money to make the girls pay part of the tuition for the term. Those who had not fully paid tuition were sent back home in the middle of the term, thus losing more time for learning. While at home, the parents and guardians could not quickly raise the money so that the daughters would return to school immediately. They would start looking at the student as a burden and should be married off quickly. In many cases, the term would end without the total amount of money being paid. There were a number of students who sit for UNEB examinations while the school fees for previous terms had not been paid. The schools would hold their results after UNEB has released them, in an attempt to recover their debt.

The extremely difficult contexts under which the female students study affect their performances at national examinations. The school climate in both schools was not conducive for learning, especially in Muni. As a consequence, their performance at national examinations was extremely poor, especially in science and Mathematics. Muni stopped admitting students for science subjects at advanced level from 1998/1999 until 2002/2003. Currently, both schools admit very few science students. Mathematics and Physics were the most 'hated' subjects in the two rural schools. Students resented combinations having both Physics and Mathematics, the essential subjects for engineering.

Performance of students at A- and O-Levels were found to differ. At O-Level, the performance at national examinations was relatively better than at A-level examinations in S6. This was due to the fact that most teachers in Muni and Ediofe were qualified and registered O-Level teachers. Both schools did not add value at A-Level. The majority of students who passed O-Level failed at A-Level. Students who intended to study at A-Level would 'migrate' from rural schools to advantaged urban schools in Central Uganda, especially in the districts of Kampala, Wakiso, Mukono and Mpigi.

4.2. Research Problem Statements

From the preceding section, it was evident that rural secondary schools in Uganda performed poorly in Physics and Mathematics subjects due to a number of reasons, the most critical ones being:

- Lack of functional senior laboratories where experiments and demonstrations could be done (the rural schools could not afford the construction of laboratories). A typical advanced level standard secondary school laboratory block for Physics, Chemistry and Biology was costing approximately 634,920 USD to build and equip. Standard laboratories are designed for a maximum of 40 students per class. In rural schools where admission of science students had been drastically reduced due to persistently poor performance in the subjects, it was not cost effective to build laboratories for a few students. There should be another innovative approach for teaching sciences in such schools.
- Many rural schools had non-functional libraries. Yet a library is a useful resource for learning and teaching. Those schools that had physical libraries could not afford to purchase text books and other reference materials. Purchasing text books was considered expensive. In situations where text books were available, they were of old editions and usually the content in them were no longer recommended by the examination body, UNEB. Building and stocking a school library with the relevant books would require about 75,000 USD. This was extremely too expensive for a rural school.
- Rural schools were unable to attract good, committed and qualified Physics and Mathematics teachers. Good teachers remained in urban or sub-urban schools where they were motivated by high salaries and other generous fringe benefits. Teachers who remained in rural schools were sometimes not qualified to teach A-level subjects. Furthermore, teachers who were teaching in urban and peri-urban schools constantly upgraded their qualifications unlike their counterparts in rural areas who did not have such opportunities.

4.3. Local Content Development

In e-learning projects, content is very vital. It was necessary to develop content based on the local examination syllabus.

Local Content Creation Workshop

In September, 2005 a Local Content Creation Workshop was organized in Arua town. The purpose of the Workshop was to let teachers develop interactive multimedia digital local content based on the national examination syllabus for A-Level Mathematics and Physics. The Workshop was facilitated by curriculum experts and programmers from the National Curriculum Development Centre, NCDC. NCDC is an autonomous corporate body under the Ugandan Ministry of Education and Sports. It took place from 5th to 10th September, 2005.

Fifty one A-Level subject teachers of Mathematics and/or Physics from 14 schools were invited to the Workshop. They were from A-Level schools located in the current Districts of Arua, Koboko and Nyadri. Only 33 teachers reported at the Workshop venue in Mvara Senior Secondary School in Arua town. Two teachers were female, the rest were male. Eighteen of the 33 teachers had taught for more than five years. This was taken as a sign of enough experience in the subject area. Unfortunately, only three of the teachers were recognized by UNEB as examiners. One of the examiners was from Ediofe Girls (for Physics Paper 2) and the other two examiners were from Arua Public Senior Secondary School (one for Physics Paper 2 and another for Mathematics Paper 2). Twelve of the teachers admitted that they were teaching in more than one school. It is common for secondary school teachers in Uganda to teach in many schools for purposes of getting more pay or remuneration. Nine of the teachers were not formally employed as teachers by the Government. They were being paid by the schools where they were teaching using PTA funds. None of the teachers admitted that he or she had wanted to be a teacher as a first choice. Teaching in Uganda is a profession that most people go for as a last resort for fear of dropping out of the education system all together. It is considered a less prestigious job. All the 33 teachers did not have the curriculum from NCDC and none had the then current UNEB examination syllabus. Finally, only 4 of the 33 teachers were able to do basic Microsoft word-processing. Basic computer skills training of the teachers needed to be done. All the teachers had no access to Internet in their schools and were unable to use e-mails.

The objective of the Local Content Creation Workshop was not achieved. The teachers were unable to create digital content of their manual notes because of low computer skills. More time was spent on teaching them basic ICT skills since they were more motivated to learn how to use computers. Yet most of them were graduate teachers.

The written/manual local content, that the teachers created, was taken to Makerere College School (MACOS) for review by senior subject teachers and UNEB examiners. Makerere College is one of the 'elite' and advantaged secondary schools in Uganda; it shares the same campus with Makerere University in Kampala. Many MACOS students pass well at A-level examinations and join Faculty of Technology for engineering training. After review of the local content created by the rural A-Level teachers, it was found that the content was shallow and lacked the necessary depth required by the examination syllabus. It was unsuitable for use for the hybrid e-learning project.

Collaboration with Makerere College School in Local Content Development

Faculty of Technology, Makerere University, contacted the leadership of MACOS to provide senior A-Level Mathematics and Physics teachers to join the project. The school accepted and attached three experienced teachers to assist the hybrid e-learning project. The Head of Physics Department, a Senior Mathematics teacher, and a Senior Physics Laboratory Technician, joined the project from March 2007. Later in the project, MACOS also attached one senior Chemistry teacher and a Biology Laboratory Technician to the project. The MACOS teachers developed all the relevant local content in the digital format for Physics Papers 1, 2 and 3 and Mathematics Papers 1 and 2.

4.4. Collaborative Development of Relevant Tools and Applications for the Hybrid E-Learning Environment

The following hybrid e-learning tools and applications were collaboratively developed by various 'communities of practice':

- The digital content materials that were developed by MACOS were used to produce interactive multimedia CD-ROMs for A-Level Physics and Mathematics.
- With support from Blekinge Institute of Technology, a website for the project was designed and commissioned; its URL is http://www.aruaeduc.com. The website is hosted by a web hosting provider, *b-one.net*.
- An open source Course Management System (CMS), the *Mambo*, was used for managing the hybrid e-learning environment.
- All the participating students and teachers in the project were given e-mail accounts to
 ease communication among researchers and co-actors (students, teachers and collaborators in the project). Some content were sent as e-mail attachments to students and
 teachers. Mobile phones and SMS text messages were also used as appropriate tools for
 communication during the project.
- All the teachers and student class leaders were given flash disks/memory sticks for purposes of transferring content retrieved from the Internet to their computers in the schools.
- Subject teachers and the students were allowed free access to resources from the Internet and project website from the Arua ICT Research Centre.
- One of the classrooms at the Arua ICT Research Centre was converted into an offline digital library. SchoolNet Uganda collaborated with the project in the establishment of the library. It donated a content server with pre-loaded science materials from 'elite' urban schools in Uganda. The server also contained science materials that SchoolNet received from other African countries. Nine computers were networked for purposes of retrieving relevant content from the server. Students and teachers were allowed free access to the digital library. The library was made offline as part of the sustainability effort of the Research Centre. Due to the high cost of VSAT connectivity fees, disruption of services due to non-payment was anticipated. The Centre was having difficulty in raising 6,785 USD per year. The local community and businesses could not afford to pay for Internet surfing at the market price. In case such interruption occurred, the students and their teachers would still access content offline.
- SchoolNet Uganda helped in the training of some participating students, their teachers and the headteachers. An *ICT in Education Workshop* for science teachers from 13 secondary schools in Uganda was held in Gayaza High School in Kampala. Muni and Ediofe participated in that workshop. Five science teachers from each school were invited. The Workshop was aimed at the pedagogic development of the teachers; to help them integrate ICT in their teaching and learning. It took place from 23rd to 25th April, 2007. There was a follow-up workshop organized by SchoolNet in Mukono District Farm Institute, on the outskirts of Kampala. The ten teachers from Ediofe and Muni again joined their colleagues from 11 other schools in Uganda. The objectives of the follow up workshop were to:

a. have a general review of the earlier workshop organized in Gayaza High School;

b. reactivate the alternative teaching and learning methods through the use of ICT;

- c. review the ICT progress in the schools from which the members were drawn;
- d. equip the participants with advocacy skills to amass reasonable support for ICT in their respective schools.

SchoolNet again invited one female science teacher and three science students of A-Level for an *ICT in Science Camp* hosted again in Gayaza High School from 7th to 11th April, 2007. Only Ediofe was invited and the three students were participants in the project. It was aimed at deepening the understanding of students in locating resources from the Internet and promoting their self-confidence in science subjects.

The head teachers of the schools being supported by SchoolNet were invited for a Workshop in Mukono District Farm Institute from 2nd to 4th September, 2007. Both head teachers of Muni and Ediofe participated. They were sensitized on the benefits of ICT in education.

To supplement the efforts of the schools with acquisition of learning materials, the following materials were purchased and distributed to Muni and Ediofe to support both the project students and their teachers:

a. UNEB physics and Mathematics examination syllabi.

b. Stationery and other scholastic materials including dissection kits for Biology students

c. MACOS local content notes for Physics Papers 1 and 2 and Mathematics Papers 1 and 2.

d. Advanced Level Physics Practicals Manual by Professor E.Banda. Students used the manual for carrying out actual experiments.

e. Arua Joint A-Level Teaching Syllabi for Mathematics, Biology, Physics and Chemistry.

f. UNEB past papers for Mathematics Paper 1 and 2 (1988-2005), Physics Papers 1 and 2 (1992-2005). Some past papers for Biology and Chemistry were also given to every student. These past papers were used as typical examination questions for students to practice and get solutions to them.

All the inferior computers of Muni and Ediofe were replaced with those having multimedia capabilities by the project. The computers were upgraded to higher multimedia capacities: hard disk drives (at least 40 MB), memory (256 MB), and processing speed of 512 MHz. They were fitted with CD drives and had sound capabilities. Digital content developed by Makerere College were uploaded onto the computers in the schools and those at the ICT Research Centre. Some were uploaded on the project website http://www.aruaeduc.com.

4.5. Rolling Out of the Hybrid E-learning Tools to Students in Muni and Ediofe

After developing all the hybrid e-learning tools, they were put at the disposal of the participating students and their teachers. The teachers were given free Internet access on working days from mid-day (noon) to 14:00 hours. They would use the time to identify relevant websites for their students, download relevant materials from websites and transfer them to computers in the schools for students to access. All Saturdays were free for students accompanied by their teachers to access resources from the ICT Research Centre. While at the Centre, a student would access content from the Internet, project website, other recommended websites by their teachers and the offline digital library. The participating students were scheduled to have their lessons in their upgraded computers in the schools. Their subject teachers would act as facilitators and provide the necessary support to those in need of assistance.

MACOS teachers were released by their school to periodically go to Arua and explain the content given to the schools which they developed. Workshops were arranged and each of the schools was hosting the exercise alternately. The following workshops were facilitated by MACOS:

- a. Practical Physics workshop was held in Ediofe from 25th to 31st March, 2007.
- b. Mathematics and Practical Physics workshop held again in Ediofe from 25th to 30th June, 2007.
- c. Practical Physics and Practical Biology held in Ediofe from 5th to 11th September, 2007. Muni was supposed to host it but their students had been suspended by the school for unclear reasons.
- d. Mathematics and Physics theory workshop was held in Muni between 21st September to 3rd October, 2007.

The participants interacted with the hybrid e-learning tools effectively from May 2007 to November 2007 when they were examined by UNEB

4.6. Repeated Measurements of Performance of Students

During the period of the intervention, the students were subjected to the following independent external examinations:

- a. MACOS examinations in May, June and September, 2007.
- b. Arua Joint District Mock Examinations in July, 2007.
- c. UNEB Examinations in November, 2007. The UNEB results were released in March 2008.

All the examinations were set, administered and marked by MACOS, Arua District Mock Examination body and UNEB using the same guidelines UNEB usually used. Note that the measurement occasions were of unequal intervals. The examinations were done at unequal intervals. Four waves of repeated data for Physics students and three waves for Mathematics students were collected for analysis. Some of the students missed some examinations due to sickness and some cases of indiscipline (especially for Muni students). Therefore, there were missing or incomplete results in the data collected for analysis. Repeated measurements taken from the same student in time with some students having missing results on some occasions made the study an *unbalanced*, *longitudinal one* with four waves of data for Physics and three waves for Mathematics. In such research designs, measurement occasions are nested within individuals or experimental units.

4.7. Performance Data Collected

All the results of the performance of the participating students in Mathematics and Physics were obtained from the respective schools. For each student, the final average standardised score in Physics or Mathematics was determined by averaging the total scores in all the papers and dividing it by the number of papers in a subject. For Physics, there are three papers and Mathematics consists of two papers.

4.8. Data Analysis

The repeated measures data that were collected were analysed using multilevel methods that were found suitable for the analysis of nested, correlated data. The analysis aimed at establishing the effects of the hybrid e-learning intervention and school contexts on the performance of rural students in Physics and Mathematics. Three individual growth models for each subject were fitted to aid the analysis.

4.9. Major Quantitative Result

The most important finding of this study was that after intensively using hybrid elearning tools and applications for six months, 41% of the Physics and Mathematics students were able to pass national examinations. Consequently, they were eligible for higher education. By predicting the performance after twelve months of using the hybrid e-learning tools and applications, it was found that up to 72% of the students would have passed national examinations, thus qualifying for admission into higher education institutions.

Chapter 5 – CHALLENGES EXPERIENCED IN TRANSDISCIPLINARY RESEARCH

5.1 Introductory Remarks

Research done in the context of application and implication of the research findings can only be transdisciplinary. There were a number of challenges experienced during the transdisciplinary research in rural Uganda. Much as the District Local Council was eager to work with the academia, there were difficulties experienced in maintaining the triple helix relationships with the District Local Council. There were also challenges that emerged and had to be addressed as the Mode 2 co-production of knowledge progressed.

5.2 Challenges in Maintaining Triple Helix Relationships

5.2.1. Arua Local Government and University Research Facilities

In Uganda, all Districts have District Information departments headed by The District Information Officers, DIOs. The Arua District Information department had a totally different expectation from the ICT/GIS Research Centre. The department was wrongly thinking that ICT was its mandate in the District and, therefore, the ICT/ GIS Research Centre had to be under the District's Information Office.

It was mentioned earlier, the ICT/GIS Research Centre was opened for public use in June 2006. All District Local Council leaders were to be trained free in Basic ICT

skills, Internet use and working with e-mails. The intention was to create a critical mass of people who would later use the facilities at the Centre. Nearby secondary school teachers and their students were also given free training. The leadership of the District Information Department did not participate in the training. Their thinking was that the ICT/GIS Research Centre was subordinate to them and could not get involved in training them. Instead, they directed the Centre to train their wives. Inwardly, we were happy with them since the decision was in line with our gender research agenda.

To facilitate fieldwork trips by researchers in the Faculty of Technology, two pick-up vehicles were purchased using Sida/SAREC funds. If a researcher wanted to use any of the pick-ups, one would apply to the Co-ordinator of the Sida/SAREC research programme, Faculty of Technology. One of the pick ups has open roof and the other has closed roof. We mostly used the closed roof pick up at the beginning of the project since it was quite convenient for transporting ICT research equipment to Arua. ICT Equipment would be safe from rain and dust but not shock due to rough road surfaces. Later during the research, we were using the second pick up because of its open roof, suitable for carrying students to workshop venues. Both schools were alternating hosting of workshops for the participating students from one school to another. If Muni was hosting a workshop at a given time, then Ediofe students would be transported to Muni daily for the duration of the event. At the following workshop Muni girls would be transported to Ediofe. Challenges came when the District Information Department started demanding that both pick ups were properties of Arua District Local Government and must not be allowed to go back to Makerere University. The Department was wrongly telling people that the pick-ups were purchased by Sida/SAREC for Arua District but Makerere University refused to hand them over to them. It took us a lot of effort to convince the Department that that was not true. We told them that the pickups were being used by twenty nine other PhD students who were being supported by Sida/SAREC as part of the research capacity building in the Faculty of Technology, Makerere University.

5.2.2. Sustainability Issue and Power Play

At the beginning of 2007, we started thinking about sustainability of the Research Centre. Staff members who were working at the Centre needed to be paid. That time the Centre was employing a systems administrator, a secretary/receptionist, armed security guards and three part-time trainers who were the nominated 'ICT Coordinators' from nearby secondary schools. The ICT Coordinators were instrumental in maintaining links between the Research Centre and their respective schools. The coordinator from Muni is still playing that role up to now. The Coordinator for Ediofe later lost interest and was the then Deputy Head teacher of Ediofe. His coordination also ended when he was transferred to act as the Head Teacher of St. Josephs College, Ombachi in 2009. Other coordinators were nominated from Arua Public and nearby Mvara Senior Secondary School. All Coordinators were trained as ICT Instructors at the Centre. Mvara Senior Secondary School is also an Advanced Level School, which is mixed (with both male and female students). But Muni and Ediofe are only for female students. The problem with mixed schools is that the boys tended to dominate the use of

ICT research equipment thus reducing the participation level of the female students. It was decided later that we only focus research in Muni and Ediofe, Mvara and Arua Public schools were dropped. This did not go down well with the schools and they decided to withdraw their coordinators.

There were other support staffs at the Research Centre as well. There were two armed local administration policemen who were deployed to provide security to the Centre at night. During the day, the Centre recruited a watchman. All the staff at the Centre had to be paid. Furthermore, the local electricity company, WENRECO, started giving us monthly bills for their services to the Centre. Water bills also needed to be paid. Equipment, mainly consisting of 57 computers, two servers and VSAT facilities, needed to be serviced and repaired. The only option left was to introduce user fees for the services being offered by the Centre. Those were bills that the Sida/SAREC would not continue to support indefinitely. We made it known to the District when we addressed the District Executive Committee in 2007. This is a committee of all heads of department and chaired by the Chief Administrative Officer, CAO. We introduced fees for Internet access and the ICT training that were being carried out free until that time. We also allowed the Systems Administrator to start offering technical and customer support services to the communities in Arua for a small fee.

The District Information Department was happy when we started charging some fees. The Department and some like-minded District officials started thinking that the ICT/GIS Research Centre was making a lot of money and they should get part of it. One day, as I was entering my office in the Faculty of Technology, Makerere University, I received a phone call from the Receptionist / Secretary at the ICT/GIS Research Centre in Arua. We had earlier assigned her the responsibility of collecting and banking the funds on the account of the ICT/GIS Research Centre. She asked me if I had authorized anybody from the District Information Office to come and get money from her. I said I did not do that. The officer also demanded that the Centre should be giving them written monthly reports about our financial performance. I advised the secretary/receptionist to request that person to call me. I did not get any phone calls from the Information Department that day. Later in the day, I went to the office of the Coordinator of our Sub-Programme in Makerere University, and shared with him what was happening in Arua. We decided to have the District Chairman know about the unfortunate demands by the Department of Information in Arua. Remember that the Chairman, Arua District Local Council, is the political head of the District. We told him what problems we were experiencing with the Information Department in Arua. The Chairman, District Local Council helped us to restrain the officers of the Information Department.

The Northern Uganda Social Action Fund (NUSAF) was a Government of Uganda Project established as a transitory tool and funding mechanism to assist the Northern Districts of Uganda to catch up with the rest of the country in matters of development. This was after the Government realized that despite significant gains in reducing poverty recorded throughout most parts of Uganda, the North had continued to lag behind and indeed fallen further into poverty. NUSAF Project was launched on 5th February, 2003. Initial Project Closing Date was 31st March, 2008 but extended to 31st March, 2009 to allow for accessing balance of the credit and smooth completion of all funded subprojects. The goal of the NUSAF project was to use targeted investments in a participatory, equitable and sustainable manner to promote reconciliation and thereby contribute to eradicate poverty in 18 districts in the North and Eastern regions of Uganda. The developmental objective of NUSAF was to empower communities in the 18 districts and consequently improving their livelihoods.

Arua was one of the eighteen Districts of Northern and Eastern Uganda that was earmarked to benefit from NUSAF project. To get NUSAF funds, organizations and institutions were required to submit fundable project proposals. It appeared that in Arua, the District Information Officer was a member of the committee that was supposed to approve projects for NUSAF funding. Some officials of the Information Office approached our Systems Administrator and requested him to submit a proposal for funding under NUSAF project. At that time our System Administrator was still very loyal to the Centre. He refused. The officers from the Information Department reacted very angrily and started threatening to dismiss him from the Research Centre. That was when the District Information Department started to control the Centre directly. Staffs at the Centre were ordered that at the end of every working day (at 5pm) all the keys to the buildings had to be taken to the District Information office. Attention of the reader is drawn to the fact that all Government offices in Uganda close at 5 pm. The staff would only get the keys back at 8.am the following morning. That instruction was impossible to implement. The Research Centre opens up to 8pm to allow the working class to use the facility after work. When I was told about the crisis, I immediately left for Arua. While in Arua, I encouraged the staff not to implement any decisions of the District Information Department. At that time while I was still in Arua, I tried to meet the leadership of the District Information Department. I needed to explain why the instruction from the Information Department was not going to be implemented. Unfortunately, I failed to get any of the officers of the Department. They all avoided coming for work for a week when I was in Arua. All their cell phones were switched off. A few times some of them had their phones on but they were not answering my calls.

Staff at the District Information Office decided to formulate another long term strategy to control the Centre. For some strange reason, they got approval from the District Executive Committee, to change the organization of the Department. The District Executive Committee is always headed by the Chief Administrative Officer, CAO. It is a Committee of the technical heads of departments in the District. CAO's position is the highest civil service job in the District. The Acting CAO who had been working with us had been promoted to a full CAO and transferred to Apac District. Under the new CAO, the relationship with the District started deteriorating further, but the political leadership was very supportive of the activities of Makerere in the District.

Under the new CAO, the new District Executive Committee approved the creation of the position of a graduate Senior Information Officer (Information Technology). The proposal was tabled by the District Information Office. The officer would be the Coor-

dinator between the Research Centre and the District. The position was advertised in the local press. The local FM Radio stations were used to inform potential candidates to apply. Details of the announcements included benefits like *'the successful candidate will be required to run the Makerere University ICT/GIS Research Centre'*. Staffs at the Research Centre were convinced that District Information Department had this time succeeded in its strange intentions.

I approached a member of the Research Centre Management Board and the Vice Chairman of the District Local Council. He expressed ignorance of what was happening. Again, the political leaders took up the matter with the Information Department. Fortunately, the District had ordered a freeze on recruitment. So the Senior Information Officer (Information Technology) was not recruited. Secondly, nobody applied since Information Technology specialists were not interested in working in rural Districts where pay was low and welfare services were poor. The position has remained vacant since it was created.

5.2.3. Disturbing Interventions by Oil Exploration Company

On 21st November, 2007, the new CAO of Arua District wrote a very disturbing letter to the leadership of the ICT Research Centre. The letter was addressed to the Coordinator of the Sida/SAREC ICT/GIS Research Sub-Programme at Makerere University, Faculty of Technology. It was delivered to the Systems Administrator in Arua since he was the one responsible for the day to day operation of the Centre. Since I was in Sweden that time, the Systems Administrator sent me an e-mail regarding the letter he had received from the new CAO. I replied to his e-mail and requested him to keep the letter until my next visit to Arua.

I returned from Sweden on 4th December, 2007 having stayed there for two months in Blekinge Institute of Technology, BTH, with my Swedish supervisor. I did not go to Arua immediately after returning to Makerere University because my mother was critically ill.

I was unable to go to Arua even in February, 2008. However, I requested the Systems Administrator to send the letter that the new CAO had written to us by GAAGA bus, a passenger bus company that is also registered to transport parcels/letters. The letter reads as follows:

'Arua District Technical Planning Committee meeting of 20th November, 2007 discussed the ICT Research Centre under minute 5/11/2007 and resolved that:-

1. There is need to get status report on the ICT Centre to reflect progress made in the District development report such as the number of teachers and students that have benefited.

2. There is need for the ICT Management Board which last met on 6th July, 2006 about 16 months ago to meet and discuss management issues and possibly to reconstitute its membership since some members could have left. 3. The District is also interested in knowing the status of the contract between the University, SIDA and other stakeholders.

4. You could also give an inventory of the equipments in place and their ownership.

The financial status report such as financial gaps and requirements of the project would also help the District to see how other friends and development partners of the District can help to support the project.

As Chairman of the management Board you could call a meeting of the Board by 11th December, 2007 to deliberate on the above issues and other issues.

The way forward could include:

- a) How the Centre will continue to operate
- b) Ownership of equipments after closure of the project
- c) Other sustainability arrangements'.

I took the letter in question to the Coordinator of the ICT/GIS Research Sub-Programme at MAK. It was signed by the new CAO of Arua District. I had not met this CAO before. The Coordinator of the Research Sub-Programme picked his phone and rang him straight away. The CAO pleaded that he was new in the District and the letter was brought to him by staff from the District Information office for signature only. We requested him not to interfere with the operation of the Arua ICT/GIS Research Centre.

The District Information Department did not stop there. Officers from that Department wanted control of the Arua ICT/GIS Research Centre. They started linking up with powerful businessmen in Arua with the intention of handing over the Centre to them. On Monday 7th January, 2008 the Coordinator of the Research Sub-Programme at MAK, who had just returned from Arua the previous day, called me to his office. He told me that while in Arua, he had met the head of Neptune Petroleum (Uganda) Ltd, the Ugandan subsidiary of Tower Resources plc. Tower Resources is a London-based independent oil and gas exploration company with a regional focus on Sub-Saharan Africa. The company holds exploration licenses in both Namibia and Uganda. In September 2005, Neptune signed a Production Sharing Agreement (PSA) with the Government of Uganda to explore, develop and produce hydrocarbons in Exploration Area 5 (Block 5), in the Rhino Camp Basin. Block 5 is a 6,040 square kilometer license area situated at the then northern end of the Albertine Graben in north western Uganda. It covers parts of the Arua, Yumbe and Moyo Districts that lie within Uganda's West Nile region. According to the Coordinator of the ICT/GIS Research Sub-Programme at MAK they had agreed in principle to form a Joint Venture company between the Research Centre and Neptune Petroleum (Uganda) Ltd. They had even fixed a meeting that Monday at 12.00 am in the offices of Neptune on Plot 5, Kitante Road, Kampala. In Arua, their office is located on Plot 70, Avenue Street. I accompanied the Coordinator of the ICT/GIS Research Sub-Programme to this meeting in Kampala. We agreed that it was healthy to partner with Neptune Petroleum

(Uganda) Ltd since its head said he had some funds to support initiatives like the ICT/GIS Research Centre as part of their social corporate responsibility. We agreed to meet again at 11:30 am on Saturday, 2008. Neptune Petroleum (Uganda) Ltd head requested for the five days so that he could consult their headquarters in the UK. My expectations were raised, thinking that at last we were going to get a wealthy partner who would alleviate some of our financial problems at the Centre. VSAT Internet connectivity, high electricity bills and the high costs of maintaining computers were the biggest problems of the Research Centre.

Our meeting on 12th January, 2008 in the Neptune offices in Kampala was very brief. The Coordinator of the Research Sub-Programme was unable to attend. Neptune Petroleum (Uganda) Ltd head appeared to have received a negative response from the UK. Since their oil exploration in Arua had not yet yielded results, he was cautioned against committing the company in such ventures. However, he promised to get us another partner. It later turned out that the new partner was the Uganda Association of Private Vocational Institutions (UGAPRIVI), which was formed to improve the quality of private vocational institutions in Uganda. Its main aim is to foster collaboration between private training institutions and to improve, not just the standards of the training provided, but also its relevance for the actual employment market. UGAPRIVI is a national organisation with regional offices in Arua, Hoima, Kabale, Kampala, Lira, Masaka and Mbale. This ensures that poorer and structurally weaker areas are not left out of the initiative.

Neptune Petroleum (Uganda) Ltd head convened a meeting between us and UG-APRIVI on Thursday 13th March 2008 in his office in Kampala at 14:00 hours. We attended this meeting since we still had hope of getting a genuine partner in running the Research Centre. UGAPRIVI officials were accompanied to the meeting by one of their major sponsors, DED, a German organization. Both sides agreed to meet again on Monday, 31st March, 2008. The only caveat was that UGAPRIVI was supposed to send to us their proposal for consideration as an e-mail attachment.

It looked as though UGAPRIVI already had the proposal written before we met them on 13th March, 2008. They circulated the proposal almost immediately after the meeting. I have reproduced the proposal hereunder:

'This proposal is that UGAPRIVI takes over ownership and control of the Arua facility under the following conditions:

- 1. Ownership of the lab- UGAPRIVI will take over ownership of the ICT lab (including all equipment and facilities) and the management of the lab. This means the existing management board appointed by MUK (Makerere University) will be no longer manage the facility.
- 2. Upon the take-over of the lab by UGAPRIVI, the already set objectives of the ICT Centre as per the agreement between MUK, SIDA and/or Arua municipality and District authorities will continue to guide the operations of the Centre.

- 3. A legal document should be prepared to transfer the lab and its equipment and facilities from MUK to UGAPRIVI giving the latter rights to management and administration of the lab to meet the originally set objectives by MUK. The terms in the legal document to be agreed upon by both parties.
- 4. UGAPRIVI prior to the change of ownership to take of the stock that will be handed over.
- 5. Existing agreement between MUK and Arua district authorities concerning the payment and rent of the existing premises will continue despite change of ownership of the ICT Centre
- 6. The Centre will be run on a purely income-generating venture to ensure sustainability of the lab in Arua/West Nile.
- 7. Upon take over, UGAPRIVI will have the right to overhaul the Centre as required to make it economically viable.
- 8. MUK may continue to conduct research relating to the centre
- 9. Equipment and facilities in the Centrellab is not transferable out of Arua after takeover by UGAPRIVI or MUK
- 10. MUK will not open a competing ICT Centre/lab in Arua. UGAPRIVI will be the exclusive ICT partner of MUK in the West Nile region.
- 11. UGAPRIVI will reserve the right to enter a partnership with third parties such as Neptune Petroleum with respect to the operations/management of the centre.
- 12. UGAPRIVI will make the centre available to Neptune Petroleum for the purpose of training teachers through a distance learning programme.
- 13. A memorandum of understanding between UGAPRIVI and MUK will be signed to stipulate the terms, duties and conditions of the handover and operations of the lab between the two parties'

The shortest meeting I have ever attended was the one to discuss this proposal from UGAPRIVI on 31st March, 2008 at the Neptune offices under the chairmanship of the head. It is also a meeting I had ever attended and I did not talk. We were very annoyed with the officials of UGAPRIVI, who were mostly of Indian origin, and their financial backers, DED of Germany. The Coordinator of the ICT/GIS Research Sub-Programme at MAK was the only one who talked. He represented our position well. He requested UGAPRIVI and Neptune not to waste our time any more. He told them off by saying that 'they were not serious'. There after, we left.

In Arua, officers at the Information Department were sure the ICT/GIS Research Centre was going to be given to UGAPRIVI who would in turn give them to operate it. They even leaked the content of the letters of dismissal of our staff who were that time at the Centre. However, luck again eluded him. At a meeting on 7th April, 2008 in Arua with the Arua District political leadership, we raised the issue of the proposal from UGAPRIVI. We were lucky at that time our Swedish collaborator from Blekinge Institute of Technology was in Uganda and she accompanied us to Arua. She attended the meeting with Arua District leadership. Copies of the UGAPRIVI proposal were given to members of the District leadership. We also mentioned that staff of the Information Department may have been involved in drafting the proposal for UGAPRIVI, since they had already shown copies of letters of dismissal of our staff at the Centre.

The District Vice Chairman called an abrupt meeting with the Mayor of Arua Municipality and summoned the head of the Information Department to join us. The Swedish professor was in attendance as the only representative of the donor- Sida/SAREC. As we all expected, the head of the Information Department accepted that he knew about the proposal from some staff in his Department. He was tasked to explain why he did not let the District leadership know about it. There were no satisfactory answers from him. He was ordered to keep his Department away from the affairs of the ICT/ GIS Research Centre.

5.2.4. More Challenges from the Arua Local Government

Another letter of even reference CR/303/2 was written to the Management of ICT/ GIS Research Centre on 23rd September, 2009 from the Office of CAO. At that time, yet another CAO was posted to Arua District. Some of his assistants took advantage of the officer being new in the District and wrote a letter to the ICT Research Centre. The brief letter titled 'STATUS OF THE ICT PROJECT' reads:

'The above project has been running for five years.

This is therefore to request you to submit a report on the status of the project to enable the District take a way forward'.

It was copied to the District Chairman, District Information Officer, Secretary to Finance and Planning, Head of Internal Audit and District Executive Engineer.

This time neither I nor the Coordinator of the ICT/GIS Research Sub-Programme at MAK reacted to this letter. We just kept quiet. We were still contemplating what our reaction was going to be since there was yet another challenge. We had dismissed the Systems Administrator. He was replaced in April, 2009.

Another letter referenced COU/112/1 had been written to the Centre on 19th August, 2009. This time it was communication from the Office of the District Chairman LC V, the political head of the District. It was titled: PERMISSION TO LABE TO USE WALL SURFACE FOR PAINTING. The contents are as stated hereunder:

'Literacy and Adult Education (LABE) is a Non-Governmental Organisation that is focused on Literacy Promoting Rights in Arua District.

The organization had secured support from the Finish NGO Foundation for Human Rights for the Children's Rights to Education Campaign in Arua.
Among the project's activities will be public sensitizations through paintings on public walls on buildings such as institution walls.

The wall of the building of the ICT Faculty of Technology (Makerere University) Arua Branch has been identified for this purpose. The Arua District Services Committee has granted LABE permission to use the wall surface facing the main road to that effect.

You are hereby informed of this development and requested to cooperate'.

The letter was copied to the District Chairman, District Education Officer, LABE and their official files.

The new ICT/GIS Research Centre Administrator objected to the plan to paint the walls of the buildings at the ICT Research Centre in kindergarten colours. LABE did not listen to the objection. They waited on a Sunday when there was no activity in the Centre and did the painting. On Monday, everybody was shocked to see the ICT/GIS Research Centre in different colours. Many people were thinking that we were paid money to allow LABE to use our walls for advertising the NGO. The District Executive Engineer himself expressed no knowledge about the decision allowing LABE to use the Centre walls for advertisement. When the letter was produced in a crisis meeting in the District, it was found that the organization was actually given permission by the District. An official of the District from the office of the District Chairman allowed the NGO to do it. Everybody kept quiet when the truth was established. The walls have remained with those paintings up to now (see Fig. 5.1).



Figure 5.1: Painting on the wall of the main building by LABE on directive from the Office of the District Chairman

We received yet another strange communication from the Office of the Town Clerk, Arua Municipal Council. The letter was dated 14th September, 2009 and referenced CR/214/20. The title of the letter was 'INVITATION OF BIDS FOR PROCURE-MENT OF CONSULTANT FOR DESIGN AND SUPERVISION OF OLUKO ROAD, TABAN LANE AND NEW LANE'. The content of the letter is reproduced hereunder:

'Arua Municipal Council has received funds under School Facility Grant (SFG)/ PRDP and intends to apply part of these funds to eligible payment under contract for design and supervision of Oluko road, Taban lane and New lane.

Your firm has been selected among prequalified firms under selective Procurement Method contained in the Public Procurement and Disposal of Public Assets Act, 2003 and Regulations, 2006 to bid for the above referenced works.

Please collect the bid document from the Municipal Cashier upon payment of a nonrefundable fee of UGX 30,000/= (Thirty thousand shillings only) and return them by Monday of 2^{nd} November 2009 before 10:00 am at which time the bids will be opened in the presence of bidders or their representatives who choose to attend in the procurement unit.

Confirm receipt of this letter immediately in writing, by cable, fax or telex. If you do not intend to bid, we would appreciate being notified in writing at your earliest convenience.'

The letter was copied to the Mayor of Arua Municipality, Head of Finance, and Superintendent of Works and Secretary of the Contracts Committee of Arua Municipal Council.

The ICT Research Centre had never applied for pre-qualification to offer consultancies for road works in Arua. Somebody may have used the name of the ICT/GIS Research Centre to get that status of a pre-qualified supplier of services to Arua Municipality. Knowing that we were tired of dragging us into corruption tendencies in the District, nobody approached us in person to submit a bid. We kept quiet and the deadline of 2^{nd} November 2009 passed without incident.

5.2.5. Security Issues

Our relationship with Arua District was also dented when we received notice on 26th February, 2008 to the effect that the District was terminating the provision of armed guard services to the ICT/GIS Research Centre from 29th February, 2008. The letter reads.

'Local Administration Police has been integrated into Uganda Police as a Department. Matters pertaining its operations and services follow under the District Police Commander's Office now.

In relation to providing security services, it has been directed that guard services end up on 29th February, 2008.

In the case of that you are advised to apply for private security firms to render security service to your institutions or otherwise.

We thank you for the cooperation you exhibited while providing security services to you'.

Providing armed security guards, especially at night, was the responsibility of the District. This was part of their contribution in the project.

The armed security services were terminated at a very wrong time. WENRECO, the sole local thermal electricity supplier, was having problems running their plant. Due to the upheavals after the disputed Presidential Elections in December 2007 in Kenya, violence erupted in that country. It took the intervention of the international community before tempers were calmed and a power sharing deal was signed. Uganda was affected since most of its imports and exports pass through the Kenyan port of Mombasa. WENRECO failed to get black oil fuel for its thermal plant in Arua. There was total darkness in the town. The plant itself was originally meant to operate only for three years from March 2003. It was already life expired and its catastrophic failure was anticipated.

With irregular electricity supply especially at night, thieves were stealing at will. Our Research Centre lost the lightening arresters for the VSAT disk twice. It was useless to install a third one knowing very well that it would be stolen. There were no armed guards anymore. A generator that we were hiring to provide electricity to the computers in the training room was stolen. Even if the suspects were arrested and jailed for six months, the theft affected our operation at the Centre. Costs went up. The number of trainees reduced because of lack of reliable electricity. It took more than two years for Makerere University to purchase a 25KVA generator for the Research Centre in Arua. The 18,000 USD diesel generator was finally installed and commissioned on 28th August, 2010.

5.2.6. Constraints in Collaboration with the Institute of Adult and Continuing Education, Makerere University

The Makerere University, Institute of Adult and Continuing Education, Department of Community Education and Extra-Mural Studies, had been renting the premises of Ozuu Brothers Enterprises (U) Ltd on Plot 10/12A, New Lane Road, Grid Building, Arua. The Institute had been renting those premises from the 1970s. Unfortunately, the landlord was complaining a number of times that the Institute was not paying rent. In many cases, rent would be paid after two years and also not the whole amount due. This forced the landlord to evict the Institute from its premises on Wednesday, 14th March 2007. The Institute representative in Arua transferred all the University property to a new place that he decided to rent using his own funds. The new place was located on Plot 36, Nysambya, along Arua-Pakwach road in Awindiri. He stayed in that building for 22 months and finally left when the University refused to refund his money for rent. This was on 16th February, 2009. This forced him to close the office of the Institute and transferred all the University property to his private home. Students could not study yet they had paid for it. The lecturers were not also being paid by the University and had left the services of the Institute earlier. The image of Makerere as a University was at stake.

I was in Arua from 25th April 2009 for four days. To prevent further negative publicity in the local press about the Makerere University, Institute of Adult and Continuing Education, I decided to offer office accommodation to the Institute representative. The only other staff of Makerere working in the Institute was a security guard. My offer was subject to the guard being deployed at night to oversee the security of the Centre. The offer was accepted not only by the Institute representative in Arua, but also his boss in Kampala, the Director of the Institute. I requested staff at the Research Centre to cooperate with the Institute representative in Arua.

However, we did not know the character of the Institute representative well before offering him an office at the Centre. His true character was made known to us immediately he was given an office. He entered into a secret agreement with one man, purportedly working with the Faculty of Law, Makerere University. We saw a short Certificate Course in Administrative Law being advertised in Arua. Applicants were being told that the course would be conducted at the IC/GIST Research Centre. Tuition fees for the three months training was to be paid in a Stanbic Bank account that the University does not know. We made this known to the Head of Department, Community Education and Extra Mural Studies, Institute of Adult and Continuing Education, Makerere University. He told us that it was not a course the Department was offering in Arua. Thereafter, the Institute representative in Arua was directed to stop it. But the damage had already been done.

5.2.7 Untrustworthy Systems Administrator at the Centre

I mentioned earlier that we had to terminate the services of the Systems Administrator at the Centre. It is true. He had developed very bad habits.

The relationship between the Centre and the community had deteriorated to very low levels. There were complaints about him by the business community. He himself started threatening staff at the Research Centre with dismissals. He ordered that no staff at the Centre should communicate anything to me. They were not allowed to call me or send any e-mails to me. He personally deleted my cell phone number from the phones of all the staff members at the Centre. While I was in Arua, none of them was allowed to talk anything to me.

The staff at the Centre met on 9th July, 2007 and sent to me minutes of their deliberations. They made sure they met secretly without the knowledge of the Systems Administrator. One of the areas they requested me to work on was '..the issue of our System Administrator needs a very close follow up as regards the disappearance of certain materials here in the Centre'.

Remember that the Systems Administrator was allowed to carry out technical and customer support services to businesses and institutions in Arua. It was within his mandate to repair and maintain ICT equipment of clients for a small fee payable to

the Centre. We made sure he had the necessary tools and equipment to do this. But he eventually went astray, completely in the wrong direction. He started his own business by using computer components at the Centre as his source of spares. He upgraded all the computers of FM Radio stations in Arua using parts from our computers. All our computers were high capacity computers with big hard disk drives, memories and high processor speeds. He was replacing components with inferior ones from his 'clients'. In some cases, he sold complete computers to his customers.

When I visited Arua from 5th-7th April 2008 together with the Swedish collaborator, we visited the Research Centre and talked to customers who were being trained at the Centre. They complained that the computers were very slow that time. Many of the computers were defective and were not being used.

I returned from Arua and escorted our Swedish collaborator to the airport on 9th April, 2008. I arranged a field trip to Arua from 20th -23rd April 2008. While in Arua, I ordered a complete technical assessment of all the computers at the Centre. Since we needed an independent technical report and upon the advice of the staff at the Centre, we used a Kenyan technician who was self employed in Arua. The staff at the Centre knew him because he was a frequent person at our premises. The technical assessment of all the computers confirmed our fears. Some computers had been sold by the Systems Administrator. They were missing from the inventory of equipment at the Centre. The other remaining ones were having low capacity hard disk drives, memories and processor speeds. The System Administrator was taking our components to his clients and returning the inferior components of clients and fitting them in our computers. This was vandalism, if not theft. The defective computers were having no components inside. They were extensively vandalized.

I had to dismiss the Systems Administrator on 22nd April, 2008 and replaced him temporarily with the Kenyan technician who carried out the technical assessment of the computers.

I returned to Arua again from 14th -19th May, 2008 for purposes of checking how the new organization at the Centre was working. I had to explain the decision to dismiss the former Systems Administrator to some of the businesses in Arua town. I and the staff at the Centre decided that we should visit Nile FM radio station.

We were received very well by the Manager, who was on duty. We asked him if the ICT Research Centre was helpful to his organization. He happily answered on the affirmative and said that *'the computers that you people supplied have solved all our problems. They are working very well*'. I requested the Manager to give us the documentation regarding those computers that the Centre supplied. He went back to the office and returned after some twenty minutes with photocopies of the transactions. The former Systems Administrator had formed his own company. He quoted for the supply of complete computers and their components. His quotation was very competitive since he was selling what was not his. Copies of the receipts acknowledging payment for computers were also given to us.

We returned to the Centre that day and found a teacher of Mvara Senior Secondary school waiting for us to register his complaint. He had two months earlier given his laptop to the former Systems Administrator for repair. He tried unsuccessfully to get his laptop back. At the Centre, no one saw any laptop that was brought for repair in the Workshop. The laptop may have been sold by the Administrator. Another complaint we registered was from Radio One FM station. The same former Administrator had entered into an agreement with the radio station to advertise his business but some bills were pending payment. Such actions were spoiling the good image of the Research Centre. Many people were happy when he was fired.

It later came to our attention that the Systems Administrator was not alone in his criminal activities. The new Administrator, who did the 'independent' technical assessment of the computers, was an active coordinator of the activities of the then Systems Administrator. They were doing the business together. The Kenyan technician would get jobs to be done and our former Systems Administrator would use facilities at the Centre to do the jobs without recording anything in the books of accounts. The ICT Coordinator for Arua Public secondary school, was also involved in the act. He would bring jobs from Secondary Schools and use the former Systems Administrator to get them done off record. Working at the Centre became difficult for both people, the new Systems Administrator who did the technical assessment that pinned his friend and the ICT Coordinator for Arua Public School. Both of them decided to quit their positions without being fired. They were replaced by recruiting two other ICT technicians.

As part of capacity development of staff at the Centre, we decided to take a lady Instructor at the Centre for a six-month course in Systems Administration in Kampala International University. She successfully completed the course in January 2009 and went back to Arua to resume her duties with a promotion as the new Systems Administrator for the Centre.

5.2.8 Sustainability of VSAT Internet Connectivity

Another challenge that the Centre has is sustainability of the VSAT Internet connectivity. AFSAT is the Internet Service Provider, ISP. The Centre pays 450 USD monthly for access of than 3,072 MB of data. Furthermore, 350 USD is paid annually as service fee. When 18% VAT is added, the Centre pays 6,785 USD annually. Clients pay for any upgrade that AFSAT makes. For example, we had to pay 767 USD for a new Satellite modem HN 77 440. In 2005, we paid 10,822.5 USD for the VSAT equipment, site survey and annual license and subscription for us to have access to broadband. The ISP is reluctant to reduce their prices from the 2005 levels, even after significant improvements in Internet backbones in the region.

In August, 2007 when we delayed to process payment to the ISP, Internet service was promptly disconnected. We had approached AFSAT and explained that we were processing the payment. But no one would listen. Disconnection was effected.

Someone suggested that we could get cheaper connection by using either Uganda Telecom Ltd (UTL) or Mobile Telecommunications Network (MTN). I requested the

new team at the Centre to get quotations from Uganda Telecom Ltd (UTL) or Mobile Telecommunications Network (MTN) for providing Internet services to the Centre.. On 28th April, 2008 I received an e-mail from staff at the Centre, with attached quotations for different speeds of internet services from UTL. The mail reads in part as

".....We have so far got quotations only from UTL. MTN does not have a resident engineer for internet in Arua. They rely on some body who is not resident here. May be you can get their quotations from Kampala. People say UTL is more reliable in Kampala and MTN is better upcountry but I have no evidence to support this. Find attached the quotations from UTL.

There is also increasing demand for the Internet and photocopying from the time people got news of the changes at the Centre and of course after the promises that there it (Internet) would be reconnected this week. May be we need to keep out promises so that the confidence in us is regained'.

After the removal of untrusted staff from the Centre, clients had hoped for immediate improvement of services.. Others were wrongly thinking that it was because of the former Systems Administrator that internet was disconnected from the Centre. This was not true.

I looked at the only quotations that UTL sent for 64, 128 and 256 kbps links. I decided that we could pay for the 128 kbps link at 843.7 USD. The amount included 510 USD for access for three months, 50 USD as set up fee, 155 USD for the ISDN NT terminal (modem) plus 18% VAT. I approached UTL head office in Kampala and they allowed me to make payment there. After payment, that was when I started regretting why we chose UTL as an ISP.

UTL staffs in Arua were reluctant to provide the service. Even the resident engineer in Arua who gave us the quotations was not willing to help us. We asked him what the problem was. He said we made a mistake by paying for the service in their head office since he was no longer going to get his 'difference'. Generally, UTL staffs do their own business within the main UTL business. This is the format our former Systems Administrator also introduced in the Centre. I am not so sure if it is not a general problem already in Uganda.

The UTL Arua staff finally connected us to Internet when their head office in Kampala put pressure on them. However, we were not getting the link we paid for. They intentionally put us on the 64 kbps link. Furthermore, the service was very unreliable; it was very irregular and unpredictable. Each time we complained, they would refer us to their head office where we made our payment. Their modems were hit by lightening twice when it was raining. They were never willing to replace the modems quickly. They would take their time before replacing the modem, which was blown. Finally, the UTL staff disconnected Internet and told us that the three months of access that we paid for were over. They started counting from the date we were given the quotations. Yet we were connected to Internet one month later. We only tolerated that 'epileptic' service from UTL for less than two months. In the final analysis, it became clear that we had to go back to AFSAT as an ISP. Even if AFSAT charges are high, the service is reliable and free from explicit corruption and gross inefficiency.

We exchanged e-mails about our predicament regarding Internet connectivity in Arua with the Swedish Collaborator in the Blekinge Institute of Technology. We needed to pay 6,785 USD to AFSAT for one year of access to broadband. She helped us out since she controls the Sida/SAREC funds for research collaboration between Blekinge Institute of Technology where she works and Faculty of Technology, Makerere University. She requested us to get an invoice from AFSAT but it should be in the names of her Institute in Sweden. AFSAT saw no problem with that. The invoice was sent and shortly after, the required funds were wired direct on the account of AFSAT. The Centre was connected back to VSAT Internet on August 11th, 2009. In January 2010, more funds were wired again as payment for the period ending August, 2011.

5.2.9 Research Cost Overruns

One of the challenges in doing transdisciplinary research in the context of the problem is that it was difficult to control costs. The budget for my PhD work was anticipated to be 78,700 USD in the proposal. Later, when I was given scholarship by Sida, the budget was revised upwards to about 1,600,000 SEK (approximately 228,571 USD) to cater for collaboration with Swedish institutions and travels to Regional Collaboration conferences. The unforeseen need to set up and operate an ICT/GIS Research Centre in Arua was not anticipated. Close to 130,000 USD additional funds were spent on establishing and operating the Centre. This made requisitions for funds for field work difficult due to cost overruns. We were all the time being reminded that we had overspent our budget. What helped us later was that some PhD students supported by Sida were not progressing. Yet their funds were available in Makerere University. Makerere University, in consultation with Sida, agreed that such funds could be re-allocated to sub-programmes that were moving faster with their PhD activities. We took full advantage of this policy shift. It enabled me to complete the PhD work within the stipulated timeframe. However, sustainability of the ICT Research Centre remains a problem without donor support. Table 5.1 shows the revenues and expenditures of the Centre during 2009.

Month	Income	Expenditures	Variance	Remarks
January	3,680,000	2,270,000	1,410,000	
Febr/March	2,470,000	3,820,000	-1,350,000	
April	1,760,000	2,105,000	-345,000	
May	2,160,200	192,700	1,967,500	
June	2,672,500	2,212,500	460,000	
July	2,887,500	2,269,000	618,500	
August	1,660,000	16,816,087	-15,156,087	Satellite modem purchased at 767 USD
Sept/Oct	4,032,500	2,608,000	1,424,500	
Nov/Dec	2,246,300	2,639,800	-393,500	
Total	23,569,000	34,933,087	-11,364,087	

Table 5.1 2009 financial performance of the ICT Research Centre

In August 2010, a 18,000 USD standby generator was installed in the ICT/GIS Research Centre to mitigate the problem of intermittent power supply by WENRECO. The generator requires a lot of funds for its operation and maintenance or service, which is done every 150 running hours. Costs for running the Centre have gone upwards, especially when fuel prices are increasing every month.

VSAT Internet access remains the biggest expenditure of the Centre at the moment. All this is happening against the fact that mobile Internet has also become so popular in Uganda. With the introduction of 3G + mobile networks in Uganda, the price of mobile internet has significantly reduced to 0.44 USD for access to 10MB of data. In Arua, it has led to a reduction in the number of clients who would come to the Centre for surfing on the Internet. It is not sustainable to have VSAT Internet in Arua. A decision will be made on what alternative connectivity is viable.

5.2.10 Unfair Business Competition

Competition as many products are released on the market is also increasing in Arua. However, competition is usually not bad, if it is done fairly.

We had a case in 2007 when the Arua District Business Information Centre was created with financial support from the United Nations Industrial Development Organisation (UNIDO). In this project, the Ugandan Ministry of Tourism, Trade and Industry (MITTI) was the national counterpart of UNIDO. Under this project eight pilot District Business Information Centres were created. Arua was one of the recipient Districts. The project aimed at providing Micro, Small and Medium businesses with ICTbased business information and solutions and ICT support. The Business Information Centre was also having sustainability problems. It was established in Arua without the communities knowing about it. It is a project that was implemented using a top-down approach. People were not using the Business Centre because of lack of awareness about it. They were going to the ICT Research Centre of Makerere University. Graduates of the ICT Research Centre were getting Makerere University certifications; which can not be compared with the ones from the Business Information Centre.

Strangely enough, the Business Information Centre started running adverts that they were part of the ICT/GIS Research Centre. The training programmes that we had at the ICT/GIS Research Centre, the times for training, and the admission requirements were copied from us. We sent one of our instructors, the ICT Coordinator from Muni Secondary School, to go under the guise of a student who needed to be trained at the Business Centre. But they were smarter. They refused to enrol him after identifying him as a 'spy' from the ICT/GIS Centre. Later, we openly talked to the management of the Business Centre and requested them to stop what they were doing. They stopped that habit. They are not running any ICT training programmes and are focusing more on small loans for rural farmers.

5.2.11 High Staff Turnovers

Changes in staff also offered a lot of challenges in maintaining the triple helix relationships. During the project, we worked with three different Chief Administrative Officers. The Resident District Commissioner was replaced once. The Deputy District Local Chairman was also replaced once.

From the side of the academia, a senior researcher of the Research team, left the services of the university. The Coordinator of the ICT/GIS Research Sub-Programme later was appointed a Deputy Dean of the Faculty of Technology. From 2009, he was again appointed as a Deputy Vice Chanchelor of Makerere University.

From the industry, the General Manager of WENRECo was replaced by a very unfriendly person from Kenya. We were getting electricity supply from the company.

These changes in personnel forced us to continuously build networks with the new incumbents. It was sometimes difficult to earn the confidence and trust of the new office bearers. We have so far failed to re-establish cordial relationships with the office of the current Resident District Commissioner.

5.3 Challenges Experienced during the Co-production of Knowledge in the Secondary Schools

Generally, carrying out research in the context of the problem gives rise to a number of challenges that need to be addressed as the research progresses. Some of the challenges are typical for such type of research. However, other challenges are unique depending of the concrete situation of the problem. In this study, some of the unique challenges were related to poverty.

5.3.1 Blind Peer Reviews

Quality control of publications is a critical concern to most scientists. For example, my PhD proposal was subjected to one internal and one external blind peer reviews. The same thing was done with the final thesis before the public defence of the PhD thesis in March, 2009. Reviews are done by 'experts' in the disciplinary area. In doing research in the context of the problem and in the context where the results of the findings are needed, quality is controlled by the co-actors in the research. They are the owners of the problem and are the ones who need the findings.

In 2007, I submitted three papers for presentation at an international conference that was organized by the Faculty of Technology, Makerere University. The papers were titled:

- Longitudinal Analysis of Performance of Ugandan Rural Advanced-Level Students in Physics Practicals
- E-learning for Development in Rural Uganda- Co-evolution in Triple Helix Processes
- Sustainability of Rural ICT infrastructure

These papers were presented at the conference. They were meant to be peer-reviewed with the intention of publishing them in a journal titled 'The Journal of Engineering, Built Environment and Technology', JEBET. This is a print journal that was established by the three technical faculties of universities in East Africa: Makerere University's Faculty of Technology in Uganda, University of Dar es Salaam's College of Engineering and Technology in Tanzania and Eduardo Mondlane's Faculty of Engineering in Mozambique. After four years, I have not received the comments of the reviewers of the papers. Consequently, the papers will never be published in that journal. May be print journals should adopt the method of open peer-reviews and open online publications of journals.

5.3.2 Methodological Pluralism

This study was strictly quantitative when I conceived the idea of improving performance of students in rural Uganda. However, in practice it was found necessary that qualitative methods had to be used before the quantitative data could be collected for analysis. There were challenges in identifying which methods should be used and when. To overcome the challenge, I had to use many methods and consequently many scientific theories were adopted at different stages of the research process. These were methodological challenges. Triple helix, participatory action research and longitudinal statistical methods had to be used in the study. Participatory and multilevel theories were the main philosophical underpinnings of the study.

5.3.3 Unpredictable Multiple Outcomes and Outputs

As a consequence of the preceding paragraph, there were more outcomes or results achieved than was originally anticipated. The biggest qualitative result was the setting up of the Arua ICT Research Centre after co-evolving in triple helix processes. Setting up of the ICT Research Centre was not in my objective in the original proposal. This later became a challenge during my PhD defence: why declare a result, which was not in the objective before? My answer was that the result was also too good to be ignored. The ICT/GIS Research Centre was helping to create an Information Society not only in West Nile region of Uganda, but in South Sudan and Eastern Democratic Republic of Congo. The Centre was helping to give youth skills and make them employable so that they stop rebellion and other anti-Government activities. It was a good result that I could not fail to highlight in the thesis!

5.3.4 Proneness to Conflicts

One lesson I learnt is that carrying out research in the context of the problem leads to a lot of conflict that must be managed continuously. It is true that we found that the teachers of A-level students were not qualified to teach at that level of education. They were unable to develop local content that we needed for the project. That is why we used the Makerere College teachers in Kampala to develop content and digitize it for the hybrid e-learning project in the schools. We even used the Makerere College teachers to facilitate four training workshops in Arua for the benefit of the female students and their teachers. These workshops were hosted alternately by either Muni or Ediofe. During the second Workshop in Ediofe from 25th to 30th June, 2007 I took two teachers from Makerere College for Physics Practicals and Mathematics.

Officers from the Arua District Information Department came to know why I was taking teachers from Makerere College in Kampala to go and support students and

their teachers in Arua. They quickly drafted an announcement and took it to the FM Radio Stations in Arua. They pre-maturely released the results of my research findings on radio. I did not listen to the announcement because I was at the Workshop in Muni. The damaging announcement was repeated three times on 25th June, 2007 at peak hours. It says the reason why students perform poorly at national examinations is because the teachers in the region were not qualified to teach and many of them were alcohol abusers. I started getting phone calls not only from the District leadership but from the schools, teachers, and the public. It was the lowest moment in the study. I explained many times that I did not put any advert on radio. The District leadership took the matter very seriously. After talking to me and finding that I did not send any announcements to the FM radio stations, they demanded officially that the radio stations must disclose the source of the announcement. They all said it was from the Arua District Information Department. However, it was a very damaging announcement to the project. It took time for us to re-build confidence and trust with the schools and their teachers.

5.3.5 Intellectual Property Rights

Issues of Intellectual Property Rights during research kept coming up. In September, 2005 during the Content Creation Workshop in Arua, some secondary school teachers wanted to be paid for developing local content. They argued that they could not give their intellectual products free. Even if their content was later found to be shallow and not good for the purpose of the project, they wanted to be paid. Later, we collaboratively produced interactive multimedia CD-ROMs using a 'community of practice' involving many co-actors. But the question of who owns the training materials kept coming up.

We set up an offline digital library for the students at the Arua ICT Research Centre. I wrote a conference paper on this and presented it at the E-Learning Africa Conference in Ghana in May 2008. When I was presenting the paper in Accra, I was asked by a participant how I was handling issues of Intellectual Property Rights and Copyright in the study. The question was asked by an elderly lady, who was seated quite close to me. I thought she was sleeping and was not even listening to my presentation. The name of the lady has slipped my mind.

Personally, I look at IPR/Copyright issues as a threat to advancement of knowledge. That is why I believe in open reviews and open publications of scientific materials. Other scientists may differ. It is an ongoing debate that is beyond the scope of this book.

5.3.6 Organisational Challenges

It was also difficult to handle administrative matters regarding the study. Too many people were involved in the research. Participants in the study included students, teachers, head teachers of schools, donors, universities, NGOs like SchoolNet Uganda and Government Departments like Uganda National Examinations Board and National Curriculum Development Centre. Maintaining harmonious relationships among such stakeholders was always administratively complex and needed a lot of time and caution. For example, the Head teacher of Makerere College was transferred in 2008 to Kitante School. The Mathematics teacher from Makerere College was also transferred to another school. The new Head teacher of the school was not very keen on continuing with the collaboration. A teacher of Physics in Muni was shifted to teach Chemistry at A-level, this made him irrelevant to the project. Yet we had been working with him well. In Muni again, a teacher of Mathematics went away for further studies during the course of the project. The Headmistress of Ediofe was transferred to Sacred Heart School in Gulu in 2008. There were constant changes in personnel that needed constant building of relationships with new people. This was challenging but we managed to keep making the right decisions at the right times.

5.3.7 Poverty and its Associated Evils

There were a number of challenges the students faced that were directly linked to poverty and its associated evils- hunger, diseases and illiteracy. During the first Workshop in Ediofe in March 2007, we realized how one of the students was struggling with practicals in Optics. She would try to locate images through a lens but was unable to see anything. A lot of tears would come from her eyes and the head would begin aching. Fellow students would put a wet piece of handkerchief on her head to reduce the temperature. When we talked to the student, we realized that the problem was with the spectacles she was putting on. The parents purchased them from a shop in town without any qualified doctor examining her. We advised that her parents should take her to a qualified medical doctor for examination before buying the right spectacles for her. This was not done. The girl remained reading using very poor spectacles bought from a clinic, which was operating without a qualified opthalmologist.

We held a Mathematics and Physics theory Worshop in Ediofe from 5th to 11th September, 2007. This Workshop was meant to have taken place in Muni, but for some strange reason, Muni had suspended almost all the project students in the school. I will come to that a little later. However, the same student with eye problems was not suspended. She was sick. She could not go anywhere. We called some of her colleagues whose homes were near to the school to join us at the Workshop in Ediofe. Some of them came from home since the school was closed to them. On 9th September, 2007 we decided to go to Muni and see the sick girl. The girls who went and saw her condition in the dormitory came and told us that the girl needed an immediate medical attention.

Nobody in Muni gives permission for a student to leave the school on a week end apart from the Head teacher. The teacher on duty could not give such permission. Yet the Head teacher herself was also not in the school. We could not wait until Monday so that permission was given to her to go out of the school for treatment.

I decided that we should break the rules and save life of a student. I requested the students who were there to go and bring her. We took the patient to Arua town for treatment. She was diagnosed with typhoid fever and given immediate treatment. I

paid for the treatment before taking her back to school. She finally recovered. That was not the only time I intervened to save life of a student.

Early that week, while we were coming out of Ediofe, I saw three girls carrying a girl who could hardly walk. Two girls were supporting her on their shoulders. The third girl was constantly dropping water into her mouth, in an attempt to make her drink. When they reached the gate to the school, the girl collapsed and became unconscious. She was entering into a coma. The third girl continued dropping water into the sick girl's mouth thinking that she would at least drink something to keep her alive before they reached the clinic. We saw the scenario and there was no need to ask any more questions.

We carried the girl and put her in the Sida/SAREC research pick-up. Within minutes, we were heading to Oriajini hospital where the two girls said she had got treatment from there the previous week. Her condition was so bad that no clinic would attend to her. She needed hospitalisation.

Oriajini is almost twenty kilometres from Arua town. From the hospital, we took her to the emergency ward. Doctors started reviving her life. We were all under tension. It took one hour before the girl started re-gaining her breath. She was diagnosed with cerebral malaria. I paid for her hospitalisation.

The problem was that we did not have anybody to take care of her in the hospital. In Ugandan hospitals, relatives and friends attend to their own patients. The hospital staff no longer do that. As we were looking for answers to this puzzle the then Deputy Headteacher of Ediofe who was with us that time, saw the grandfather of the girl coming to the hospital. He immediately approached the old man and narrated to him the story of how his grand child ended up in the hospital. We immediately handed over the responsibility of looking after the girl to him. This was the first life we saved that week. The Muni life we saved was the second.

Epidemics are common in Arua. On 5th February, 2007 schools in Arua did not open for first term due to Meningitis outbreak. They opened one month late after massive vaccination of the people had been done by Government.

Towards the end of the restriction, I had to travel to Arua from 12^{th} March to 16^{th} March 2007 to arrange the first Workshop to be facilitated by Makerere College teachers. The Workshop took place from $25^{\text{th}}-31^{\text{st}}$ March, 2007.

While in Arua, I and the driver of the open-roofed Sida/SAREC research pick-up, had to be vaccinated against meningitis from the Arua Teacher's Resource Centre in Muni National Teachers' College.

In 2007 and 2008, there was persistent outbreak of cholera epidemics in Arua District. Up to twenty people were killed in the epidemic. Arua District Director of Health Services attributed the unending cholera breakouts to poor sanitation and high illiteracy rate in the district. He said that a lot of garbage in and around the town and its suburbs were the major causes of the persistent cholera in the West Nile region. The garbage had attracted a lot of green house flies and maggots that had even scared

away the customers from eating places. In 2009, there was an outbreak of yellow fever in Northern Uganda and forty five people have died of the disease. Arua is one of the Districts affected by the outbreak of yellow fever.

Even if we got vaccinations against meningitis and cholera, doing research in Arua was difficult since we were not sure of what might happen next. To the students, learning times were reduced since during outbreaks of epidemics, schools would be closed.

The road to Arua passes through many poor and insecure rural Districts. Sometimes in those Districts, epidemics also break out. The road to Arua passes through Gulu and Masindi Districts. Epidemics are frequent in those Districts. An outbreak of Ebola disease was reported from Gulu district, Uganda, on 8 October 2000. The outbreak was characterized by fever and haemorrhagic manifestations, and affected health workers and the general population of Rwot-Obillo, a village 14 km north of Gulu town. Later, the outbreak spread to other parts of the country including Mbarara and Masindi districts. The medical superintendent of Lacor Hospital in Gulu and 24 other nurses died while fighting the disease. Many people died of ebola in Uganda that time.

Poverty and poor hygiene are the underlying causes of plagues. Human plague follows exposure to wild rodents or fleas and the incubation period is one to seven days but may be longer. There was an outbreak of plague in Masindi District in February 2007. We had to postpone a trip to Arua because of that epidemic which had already claimed nine lives.

5.3.8 Industrial Action

More learning periods were lost in 2007 when all secondary school teachers in Arua District took industrial action. They had not been paid their June salaries. All secondary schools in Uganda are under the Central Government. They were not decentralized. The salaries of the teachers are sent to the District, which in turn pays the teachers.

The Central Government insisted that they sent the salaries to the District. The District said they did not receive the June pay cheque. However, July and August 2007 salaries were paid normally but no one was telling teachers where the June salaries went. When there was no satisfactory answer about the missing June pay cheque, they resolved to lay down their tools.

At the beginning of third term, 2007, all the secondary school teachers in Arua were on strike. They were demanding payment of their June salaries. Students were not being taught. We could not schedule any activities in Arua due to the industrial action.

5.3.9 Leadership Styles

Management and leadership styles of the two schools were also very different. In Muni, the leadership was based on fear and lack of trust. The headteacher, staff and students were always antagonistic. Suspensions of students were frequent. A student on the project was always under suspension for very minor offences. She missed some of the Workshops and external examinations that her colleagues were involved in. We mentioned earlier that almost all the students were suspended at the end of second term for 'indiscipline'. That is why when we were at a Workshop in September 2007, Muni project students were on suspension. The reason for the suspension was trivial. Students were allocated dormitories according to classes. So Senior 5 (S5) girls were sleeping separately from Senior 6 (S6). But that day, the school directed that one girl of S5 should shift to where S6 students were sleeping. No reason was given. The S6 girls refused. They said the S5 girl was a 'spy'. They removed her belongings and returned them to where all S5 students were supposed to be. The school felt that S6 students had no right to challenge authority. Most of the S6 girls were suspended for two weeks before the end of the second term. They were to report back with their parents at the beginning of the third term. Unfortunately, at the beginning of the term their teachers were on strike as well. The dilemma of the girls continued and more learning time was lost.

5.3.10 Alcohol Abuse by Teachers

Some teachers, especially in Muni, were openly abusing alcohol and would come to teach while drunk. The former head of Department of Biology in Muni had drinking problems.

There was a time when we arranged some additional Workshops for students of Chemistry and Biology in Muni. The schools requested that we should not only focus on Physics and Mathematics. They needed help in the other science subjects as well like Chemistry and Biology. We agreed to that request.

For Biology, we arranged the first practical session- dissection of amphibians. The previous evening, we gave the then former Head of Department of Biology the money required to buy frogs for each of the Biology students. This man did not turn up in the morning when the students were supposed to start the practical lesson. He used the money for buying alcohol for himself. He appeared in the school at 1pm- very drunk. It was a very boring scene. This was a demonstration of total lack of control in Muni. On the contrary, the leadership in Ediofe was more open and more participatory.

5.3.11 Enmity between Schools

Muni and Ediofe were enemies. We did not know about this until we started implementing the project in the two schools. The reasons are not clear to me up to now. Some say it may be because of religion. Ediofe was headed by a Catholic nun. Muni was headed by a born again Christian. The hatred between the two schools was quite bad. The relationship sank so low during Arua District Sports day in 2007. All secondary schools in the District are usually required to bring students for sporting activities to the District headquarters.

During 2007 Sports Day, one student of Muni fought with another from Ediofe. The student from Ediofe lost a tooth. The girl was rushed to the hospital and doctors advised that an artificial tooth should be procured to replace the missing one. The parents of the affected girl were also very unhappy that their daughter lost a tooth under unclear circumstances. Attempts to talk to the Muni leadership about this incident yielded nothing. The school refused to pay for the purchase of the artificial tooth. Ediofe paid in order not to prolong the agony of the student and her parents. The matter was referred to police since it was an assault case. Muni said they were ready to sort out the case in court. However, Ediofe dropped the case because there was very little sense in it.

Bringing the two antagonistic schools to work together in a project was extremely difficult. The first time we held a Workshop in Ediofe, we went and collected the Muni girls very early using the Sida/SAREC pick-up. To our surprise, all the girls from Muni refused to take breakfast in Ediofe. They were told not to eat anything while in Ediofe. We intervened. We talked to the students to live with one another freely for purposes of implementing the project. They understood us. The next Workshop was in Muni. The girls freely mixed with each other. We succeeded in bringing the students and teachers of two antagonistic schools to work together. Finally, we brought both head teachers for training in Kampala in September 2007. After their Workshop, I picked both of them in my car and took them to my house. This happened on 4th September, 2007 at 5pm when I picked them. The following day, I left for Arua for a Workshop that was to be hosted in Muni. When I reached Muni, I found that the school had suspended almost all the S6 girls. To make it annoying, the head teacher of Muni was in my house the previous evening and did not tell me that the students had been sent home. We had to shift the venue of the Workshop to Ediofe, since their students were at school. However, Arua District commended us for bringing the two antagonistic schools to work together. But the task was not easy.

5.3.12 Difficult Socio-Economic Status of the Students

Some students in the project had very difficult backgrounds that were affecting their studies. One female student of Ediofe was rejected by her father. The man totally did not want anything to do with his daughter. When Ediofe approached him about the tuition of the girl, he warned the school never to call him again. Yet the father was a police officer in Masindi District. The head teacher of Ediofe started paying tuition of the girl from the last education cycle, O-level.

A few of the students were total orphans, having lost both parents. During school holidays, they would have nowhere to go.

5.3.13 Insecurity and Insurgency

Arua is a poor, remote and insecure rural District located in the West Nile region of Uganda. It is 500 kilometres from Kampala, the capital city of Uganda. According to the results of the 2002 National Population and Housing Census, the district has a total of 855,055 people with 445,852 females against 409,203 males. However, the population is poor with a low socio-economic status. The District shares a common border with the Democratic Republic of Congo (DRC). Its northern part is near the border with Sudan. Armed conflicts in both countries frequently spill over to Arua District. The District is also home to a large group of South Sudanese rebels who were resettled there in refugee camps. Historically, Arua citizens themselves rebelled against

successive Ugandan governments. The Uganda National Rescue Front (UNRF) refers to two former rebel groups UNRFI (1980-1985) under General Moses Ali, and UNRF II (1996-2002) led by Major General Ali Bamwoze. The West Nile Bank Front (WNBF) under the late Colonel Juma Oris (1995-1998). These rebel groups finally signed peace agreements with the Ugandan Government. However, some of the former rebels appear not to have handed over all their guns to the Government. They hid them. Such illegal guns cause a lot of insecurity in the area. Influx of small arms into the area is also being blamed on armed conflicts in DRC and Southern Sudan.

The Lord's Resistance Army (LRA) under the command of the self styled General Joseph Kony has been fighting with Ugandan Government troops since 1987. LRA operates mainly in the Acholi sub-region, on the way to the West Nile District of Arua. It is Africa's longest running conflict at the moment. The International Criminal Court (ICC) has indicted five leaders of LRA. Arrest warrants were issued for them. They were charged in 2005 with crimes against humanity and war crimes, including murder, rape, sexual slavery, and enlisting of children as combatants. In 2006, the LRA started holding peace talks with Uganda Government in Juba and there was some fragile peace holding in the region. Ceasefire agreements were signed and hostilities have stopped. But the security situation remains volatile since the two sides failed to sign any peace agreement. The LRA leader failed to show up for the signing ceremony of the agreement. Before the start of the peace talks, passing through the Karuma - Pakwach stretch of the road where the rebels used to be active was very difficult for us. We would pray to the Almighty while passing in that area of the park on our way to and from Arua. Moving along Karuma-Pakwack road was very scaring. Only the strong hearted could dare. The LRA rebels wanted to close the road. This would effectively cut of the West Nile region from the rest of Uganda. Government soldiers could not allow this to happen. They took control of the road. Every morning, soldiers deployed at intervals from Karuma to Pakwach, a distance of approximately 100 Kms. They would confirm that there were no rebels before vehicles were allowed to enter that stretch of the road. In extreme circumstances, all vehicles were escorted by military convoys. Any vehicles that missed the convoy from either Karuma or Pakwach were not allowed to proceed. Also, any vehicles that arrived at any of these places after 2pm were not allowed to proceed. Such passengers would spend the night either in Karuma or Pakwach. Meanwhile, moving in convoys was also not enough guarantees to safety. A number of times even military convoys were being attacked. Lives were lost. Properties were damaged. Skeletons of burnt down buses, trucks and saloon vehicles was a common sight along that stretch of the road between Karuma and Pakwach. People were abducted and conscripted into rebellion.

One time in 2006 we actually met the rebels. I was with my wife and the Sida Driver. That time, I had decided to go to my home in the village in Pader first before going to Arua. I had wanted to see my people in the village. That time the rebels had signed a ceasefire agreement with Uganda Government. So they were peaceful. We left Kalongo for Olwiyo via Kitgum Matidi, Acholi Bur, Gulu, Koch Ongako and Anaka. Olwiyo is a junction along the Karuma-Pakwach road. Somewhere around Kitgum Matidi, we saw the rebels. They were by the road side. They did not stop us but waved to us. They were really peaceful that time.

Despite the difficult security situation in Northern Uganda that time, we did not stop our research. We stayed the course.

Chapter 6 – CONCLUDING DISCUSSIONS

6.1. Basic and Applied Research at Makerere University

Makerere University does mostly basic and applied research. The research is heavily supported by donors, mainly Sida. However, attention of the reader is drawn to the fact that it is difficult to apply the results of basic and applied research. To let the public know that the findings exist, the university disseminates the results in conferences, Workshops and seminars. The results may also be published in peer-reviewed journals for like-minded academics to read and update their understanding in the subject area. Therefore, basic and applied researches are not immediately relevant to practice or development. It takes long to go from research to practice. In the contemporary competitive economy, research should be more important, more relevant and more practical than ever before. Yet, there should be interplay between theory and practice.

Basic and applied research may lead to some innovations. According to Dosi (1988) innovation is the search for, and the discovery, experimentation, development and adoption of new products, new production processes and new organizational set-ups. Chesbrough (2003) calls the type of basic and applied research done by traditional universities, which does not result in simultaneous use of the research findings as 'closed innovations'.

Makerere University has accumulated lots of closed innovation results that need to be utilized in society. Many traditional universities call such efforts of applying closed innovation results or findings differently. Some call it outreach services to communities, knowledge transfer partnerships, public-private partnerships, commercialization of research results. It is not easy to commercialise research findings that resulted from closed innovation.

6.2. Action Research more Relevant

The 21st century universities have created their own 'oppositions or competitors'. Universities have curricula that contain courses in Research Methods. University graduates leave universities with a lot of research skills. When they get employed, some of them establish Research and Development Departments. A lot of research is now being done outside the academia. A few examples will help to re-enforce this point. Many multinational companies have fully fledged departments for Research and Development. I used to work for Bombardier, a Canadian company dealing with locomotives and air transport. This company had a Research Institute. A motor company like VOLVO has its own research department.

In Uganda, Government Ministries and Departments, newspapers, kingdoms, banks including the central bank, some businesses and political parties also have research and development departments. Joint Clinical Research Centre (JCRC) conducts research on HIV/AIDS and has centres in Kampala and other parts of the country. The National Agricultural Research Organisation, NARO, is an umbrella organization comprising of nine Research Institutes, which constitute the technical arm of research, each with a varying research mandate. An Act of Parliament established NARO on November 1, 1992 by amalgamating several research institutions that existed within several Government Ministries. The result is a research body comprising nine Research Institutes and eleven Agricultural Research and Development Centres. Policy makers say, "The overall goal of research is to address the challenges presented in the Plan for Modernisation of Agriculture, PMA, and to provide research services that address the needs and opportunities of the majority of the poor in a sustainable manner". The ultimate objective of NARO is "to enhance the contribution of agricultural research to sustainable agricultural productivity, economic growth, food security and poverty eradication through generation and dissemination of appropriate technologies, knowledge and information". There are six National Agricultural Research Institutes (NARIs) in Uganda. Each of these institutes manages and executes agricultural research of a strategic nature and national importance. They do specialized research in crops improvement, fisheries, forestry and livestock (their health, breeding animal nutrition and apiculture development). One of the research institutes is Serere National Semi Arid Resources Research Institute (NaSARRI) situated in Serere in Soroti District in Eastern Uganda. It undertakes research in semi arid areas of Uganda. The National Agricultural Research Laboratories are located in Kawanda Research Station, the administrative home of NARO. NARO also has the National Agricultural Biotechnology Laboratory (NABL) with the following units: Biological Control Research Unit, Post Harvest Research Unit, Soils and Soil Research Unit, Plant Genetic Resources Programme and Botanical Gardens. Newspapers like Monitor Publications Ltd and

New Vision Publications Ltd frequently commission specialized research companies to carry out research on topical issues. For example, TNS/Research International, an independent global research company with offices in more than 90% of the countries of the world, is usually contracted to do research for their clients. Afrobarometer is another international company that does contract research.

From the foregoing, the days of the 'ivory tower' mentality of doing basic and applied research in laboratories on campuses in Universities are getting extinct. In the competitive knowledge economy, research that leads to development (simultaneous use or application of research findings) must be done within the economy- in industry and businesses. The knowledge age is the period of uncertainty. A lot of knowledge is in the open. Knowledge generation and dissemination is no longer the exclusive right of the academia. Governments are interested in research that leads to generation of knowledge and technologies for socio-economic development of the country. The research, therefore, must be in line with the overall National Development Plans of the country. Therefore, universities in the modern world must learn to be part of the society. They are part of the community. To participate in the transformation of the largely rural economy (based on subsistence agriculture) to the knowledge economy, universities should do research in collaboration with industry/businesses and Government. This alliance between the academia-industry-Government is what Etzkowitz and Leydesdorff (1997) called the 'triple helix'. Triple helix relationships are important for two reasons: they stimulate innovations and sustainability- the two triple helix twins (Etzkowitz and Zhou, 2006). In the university-industry-Government alliance, research and development (or theory and practice) can proceed concurrently. Knowledge generation and immediate utilization of research findings happen at the same time.

6.3. Triple Helix in Practice

Makerere University, Faculty of Technology, successfully entered into a triple helix relationship with Arua District Local Government and the local business communities there. The result was the establishment of the Arua ICT/GIS Research Centre. The Centre was later used for development purposes: creation of an Information Society not only in the West Nile region of Uganda, but also in South Sudan and Eastern Democratic Republic of Congo. VSAT internet connectivity in the Centre was used to introduce hybrid e-learning in Muni and Ediofe for the benefit of disadvantaged students who were not expected to pass and get admission for further education. In the hybrid e-learning project, the main course delivery platform was the interactive CD-ROMs since the schools and the students themselves could not afford broadband connectivity in their homes or schools. Up to 41% of the female students passed and were eligible for further education. This was after six months of effectively using the hybrid e-learning tools. Results showed that if they had used the tools for an additional six months, up to 72% of the students would have passed. However, due to very difficult situations of some three students, they would never have improved well enough to pass national examinations. This finding may raise a wider policy debate whether the duration of advanced secondary education should be reduced from the current two

years to, say, one year since more than three quarters of the students can pass within one year of using e-learning tools. The findings should also help the Ministry of Education to consider introducing a policy on e-learning in the Ugandan education system. Government and policy makers may also use the findings and start introducing an open education system in Uganda. With the population increasing without control, it becomes difficult to offer adequate social services, most especially education. It is no longer possible to put all students in physical structures like classrooms, laboratories, and libraries for purposes of delivering face-to-face instruction. The days of the closed education system are numbered.

This study was linked to the following international, continental and national obligations of Uganda Government:

- At the Millennium Summit in September 2000, the largest gathering of world leaders in history, adopted the UN Millennium Declaration, committing their nations to a new global partnership to reduce extreme poverty by half and setting out a series of timebound targets, with a deadline of 2015. The Declaration has eight Millennium Development Goals (MDGs) that must be achieved by UN member states.
- The UN twin World Summits on the Information Society (WSIS), 10-12 December 2003 – Geneva, Switzerland and 16-18 November 2005 – Tunis, Tunisia, agreed to mainstream ICTs as the only progressive tool that must be used to accelerate the achievement of the Millennium Development Goals.
- The New Partnership for Africa's Development (NEPAD) e-Schools Initiative was publicly launched in Durban at the Africa Summit of the World Economic Forum on June 12, 2003. The Initiative has been adopted as a priority continental undertaking aimed at ensuring that African youth graduate from African schools with the skills that will enable them to participate effectively in the global information society. The aim of the initiative is to impart ICT skills to young Africans in primary and secondary schools as well as harness ICT technology to improve, enrich and expand education in African countries. The NEPAD eSchools project is being piloted in Uganda as well. Six primary and secondary schools per country are involved in the pilot phase. In Uganda, they are Kyambogo College (where the headquarters of the project are located in Uganda), Masaka Senior Secondary School, Bugulumbya Senior Secondary School, Bukuyu Senior Secondary School, St. Andrew Kaggwa Senior Secondary School and Kabale Senior Secondary School.
- The Poverty Eradication Action Plan (PEAP) of Uganda Government, which is now contained in the National Development Plan 2010/11 to 2014/15.

This study used VSAT as a tool for addressing MDG no.3 by attempting to promote gender equality and empowering women in Uganda. Hybrid e-learning was introduced in two secondary schools – Muni and Ediofe. This is additional to the six schools under the NEPAD e-schools project. The project was also linked to pillar number 5 of PEAP where Uganda Government committed itself to the human development of its people.

6.4. Innovative Clusters

Universities can meaningfully contribute to the socio-economic development of a country through clustering. According to Porter (1998) clusters 'are geographic con-

centrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in particular fields that compete but also cooperate'. Clusters are usually existing but what is lacking are the cluster initiatives which are 'organised efforts to increase growth and competitiveness of clusters within a region, involving cluster firms, government and/or the research community', Solvell, Lindqvist & Ketels (2003). Therefore, in a cluster initiative the key stakeholders are the triple helix partners-the academia, industry and Government. Open innovation is increasingly being based on the 'triple helix' of academia, industry and Government relations. The main purpose of cluster initiatives is open innovation. Note that enterprises (businesses and industry) are the true agents of open innovation and they must be encouraged to play a central role. In the knowledge economy, the academia can play a role in the cluster initiatives with the main aim of innovating: generating new knowledge and technology in the contexts of the problems and in the context of application and implication of the research results. This makes the research transdisciplinary.

One characteristic of innovation is that it is not linear. While many innovations or technologies depend on advances in basic and applied research, some do not, especially when the research is transdisciplinary. Sometimes technology development comes first before the knowledge is generated. For example, steam engines were developed, op-timized and widely used before the establishment of thermodynamics- the field of scientific knowledge that explains how they work. Containers, an innovation that is responsible for genuine revolution in transportation by reducing transit times of goods, required no scientific knowledge or even any meaningful applied research. Indeed, the development of several new scientific fields has itself been a consequence of technological advances. So the linear model is an oversimplification of reality. In the hybrid elearning study, we first produced the interactive CD-ROMs and established the ICT/GIS Research Centre before looking at the theories that supported our results. I did not know about 'triple helix' before. It was my Swedish supervisor who gave me the name of what we had already achieved. Therefore, innovations in a transdisciplinary research may follow a non-linear path.

6.5. Open Innovation

Open innovation (Chesbrough, 2003) is a paradigm that assumes that firms can and should use external ideas as well as internal ideas about the market, as the firms look to advance their technology. It is characterized by:

- Use of internal and external Research and Development (R & D) and inventions- corresponding to the particular business model
- Openness to external business models
- Variety of Intellectual Property generators and collaborators like other companies, public universities, R & D institutions, users, customers, suppliers, etc
- Access to and transfer of technologies is an important issue

- Intellectual property like research finding is an asset, which can (and should be) managed through an adequate business model to increase value and become a reliable source of revenue. This is sometimes called commercialization of research findings.
- Active Intellectual Property asset management of the companies' Intellectual Property portfolio by matching technologies with innovative (inside or outside) business models to add value to the Intellectual Property

Open innovation is done externally with other partners. The innovation also becomes obsolete rapidly. This is a more relevant type of innovation in the knowledge economy. Today, technology and innovation have big knowledge contents. Businesses must embrace open innovation. In the knowledge economy, universities are looked at as sources of knowledge. Expectations of Governments and Industry have changed from education to partnerships in triple helix with universities. This is a new trend world wide.

Theory of open innovation means that everything is done outside the business; R & D is open for different partners. Competitors work together to develop complicated solutions. Open innovation opens avenues for people to work together. Universities, businesses and Governments work together as part of one market. The logic of open innovation is premised on the fact that:

- Good ideas are widely distributed today. No one has a monopoly on useful knowledge anymore.
- Innovation is now done within networks of firms, rather than within a single firm
- Not all of the smart people in the world work for a particular firm. They work for many other firms.

6.6. Situated Knowledges

When carrying out transdisciplinary research, it is very important to situate yourself in the context of the problem and the context of application and implication of the research findings. Without context, information is meaningless. In the wrong context, information is misleading. "I should venture to assert that the most pervasive fallacy, of philosophic thinking, goes back to the neglect of context" (Dewey, 1931). Cronbach (1975) maintain that 'generalisations decay' especially in qualitative studies. What Cronbach (ibid) meant is that generalizations are fallible and subject to change over time

Lave (1988) argued that learning takes place as a function of the activity, context and culture in which it occurs. Learning is thus "situated" within a definite social and cultural context, and domain of learning. This contrasts with most classroom-based learning activities in which knowledge is abstract and presented out of context. According to Lave (ibid), social interaction is a critical component of situated learning. Learners become involved in a "community of practice" which embodies certain beliefs and behaviors to be acquired. At the outset, learners begin their journey at the periphery of this community and progress toward the Centre as they become more active and engaged within the culture. They move from being a newcomer or novice toward

assuming the role of expert or old-timer. Moreover, situated learning is usually not directly taught but is unintentional, occurring through active participation in working together with other people. These ideas are what Lave and Wenger (1991) referred to as the process of "legitimate peripheral participation". Such participation is socially interactive in nature, involving an apprenticeship and guided participation between 'newcomers' and 'old-timers' within the educational community.

Lave (1988) is often credited with starting the situated cognition movement, although its ideals are not new. Dewey (1931) and Vygotsky both advocated similar approaches. Lev Vygotsky's (1978) concept of 'zones of proximal development' suggest we design authentic tasks that are more difficult than students may handle alone, but not so difficult that they can not be resolved with the support of peers or teachers who model appropriate strategies. Dewey was an advocate of situated approaches to learning, arguing that understanding is defined within a social context. According to him learning cannot be defined by outsiders (each student will learn to read by method X), but rather, emerges via collaboration (how reading supports us).

For Vygotsky, cognitive development occurs within a social context. Rather than construct methods of cognition as an individual, the child appreciates ways of thinking through social interaction. A society is produced through the construction and use of cultural tools like language. These tools are acquired during a culture's development and forwarded to subsequent generations. As culture develops, new generations may adapt a cultural tool. This is called appropriation.

Generally, a social constructivist method presents a more accurate examination of cognitive development than a Piagetian constructivist approach. Indeed, any study of child development must consider the social and cultural perspective.

The main part of the R&D work in the hybrid e-learning project was based on the methodologies characterising distributed knowledge processes (Gibbons et al. 1994, Nowotny et al. 2001). The research was anchored in technoscientific gender research (Trojer 2006) with connections to the tradition of action research methodologies.

Situated knowledge production was a key concept as well as a practice. It refers to the acknowledgement of an empirical inside perspective. You have to be inside what is being developed concretely on the ground in order to be able to understand some of the complex web of processes going on. Research must focus on the context of production as well as context of implication (Nowotny et al., 2001, 2003). Or as Haraway (1997) notices "Technology is not neutral. We're inside what we make, and it's inside us. We're living in a world of connections – and it matters which one gets made and unmade". Gulbrandsen (2004) emphasizes the character of research as reality producing or world producing.

The hybrid e-learning project was strongly dependent on an implemented practice of a triple helix cooperation. A number of important questions about new challenges arose, when participating in such an open system for knowledge production and development of activities (Nowotny et al. 2001, 2003). Perhaps the main challenge was realis-

ing that we were taking part in non-linear processes. Development occurred through co-evolution yielding specific results within the different actors' respective areas of activity. Co-evolution entails stronger requirements for change in the respective organisations / sectors. We also noticed that what we were doing comprised an integration of knowledge production and policy production. Or to put it another way – research and policy are connected.

Innovation entails production of uncertainty and complexity, renewal and change, and is often presented as worth striving for in Government policy. Miettinen's (2002) discussion of the new models of cooperation between academia, industry and government can be seen as opportunities for collaboration, where the parties' legitimacy, trust and "social capital" must continuously be recreated. This partnership can thus come to play a central role in the development of socially robust knowledge and technology

Under 'mode 2' knowledge production, many people participate in the research and quality control is open to reviews by a cross section of participants in the study. Jasanoff (2003) argues that it is necessary to increase civic participation in the governance of science to compensate for the erosion of the authority of technical experts, and urges the adoption of what she calls 'technologies of humility' which engage the human subject as both active agent and source of knowledge and insight. The author maintains that science and technology must be socially relevant and responsible. This is in sharp contrast to an earlier thinking of Roll (1986), which showed lack of humility and excessive arrogance exercised during corporate take-overs.

It should be mentioned that in this study, it was impossible to only use 'mode 1' linear thinking based on the approved PhD research proposal. The study co-evolved into 'mode 2' knowledge production and technology development (like the production of interactive training CD-ROMs). It means that 'mode 1' thinking is essential but not sufficient for purposes of carrying out research in the context of the problem.

There is an ongoing debate in the academia regarding the differences between 'mode1' and 'mode 2' thinking. Critics of 'mode 2' advance common challenges of this type of thinking as lacking rigour in quality control of the process, methodological pluralism, many unforeseen outcomes and conflict-prone. However, this study found that, when carrying out research in a remote, poor, rural and insecure context, poverty-related challenges need to also be addressed since they impact on the co-production of knowl-edge. Diseases, epidemics, socio-economic status of co-actors, insecurity, unprogressive culture and tradition eventually affect knowledge and technology production.

When carrying out research in the context of its application and implication, participatory methods should be used. It is one of the methods of action research. The method aims at participation of the researched people in the research process. This leads to filling of some of the power gaps between the researchers and the researched people. In this case, the researched people are active participants rather than passive objects of the research. The research process is cyclical and includes identifying the research questions, planning and designing the research, collecting data, analysing and interpreting the data and sharing the results. When the research participants can share their inputs based on their own experiences, the research can create relevant knowledge for them.

6.7. Philosophical Underpinnings of Transdisciplinary Research

Action research is a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems. The origin of 'action research' can be traced back to the works of Lewin (1946). Lewin, then a professor in MIT, argues that research that produces nothing but publication of books and journal papers will not suffice. Action must be taken by disadvantaged people with a view to change their situation.

Action Research has evolved through the 1990s and into the 21st century as it has been applied within the international development. There are a number of participatory theories that can be used depending on the contexts and situations. Argyris, Putman and Smith's (1985) Action Science is helpful in the study of how human beings design their actions in difficult situations. The Living Theory proposed by Whitehead and McNiff (2006) presupposes that individuals generate explanations of their educational influences in their own learning, in the learning of others and in the learning of social formations. They generate explanations from experiencing themselves as contradictions in enquiries of the kind, "How do I improve what I am doing?'. They use action reflection cycles of expressing concerns, developing action plans, acting and gathering data, evaluating the influences of the action, modifying concerns, ideas and action in the light of the evaluations. Torbert (2004) proposes the Developmental Action Inquiry as a way of simultaneously conducting action and inquiry as a disciplined leadership practice that increases the effectiveness of actions of leaders of organizations. This Action Inquiry attempts to interweave individual's first-person self study with face-to-face second person self-study by teams and with a third-person institutionwide self-study. Such actions help individuals, teams and organizations become more capable of self-transformation and thus more creative, more aware, more just and more sustainable. According to Torbert (2004) 'if you are not part of the problem, you can not be part of the solution'. Heron (1996) calls it Cooperative Inquiry. However, in this study, Freire's (1970) Participatory Action Research (PAR) was adopted. This technique builds on the critical pedagogy put forward by Paulo Freire as a response to the traditional formal models of education where the 'teacher' stands at the front and 'imparts' information to the 'students' that are passive recipients. This technique was further developed in 'adult education' models throughout Latin America.

6.8. Final Conclusions

In conclusion, I would like to state that research done in the context of the problem and in the context of application and implication of the research findings can only be transdisciplinary. This type of research, which uses participatory theories usually leads to co-evolutions. While 'mode1' methods of knowledge and technology production are necessary in transdisciplinary research, they are not sufficient without 'mode 2' methods. Both methods of thinking should be used for the simultaneous production and utilization of the research findings- knowledge and technology-in the social context of the problem.

The only way universities can be relevant to the modern societies is to enter into triple helix alliances with governments and businesses or industry. Triple helix relationships are important for purposes of sustainability and open innovations. However, this is a very complex alliance and maintaining such relationships are difficult. Challenges that come up must be continuously addressed. Otherwise, they may grow to un-manageable levels.

If the objective of the triple helix relationship is to stimulate innovations within the business or industry, innovative clusters must be formed. Clustering of businesses should be based on the triple helix methodology.

The academia should start thinking outside their strict disciplinary positions. It is common in the academia to find that staffs from science and technology-based faculties have nothing to do with qualitative research approaches. The reverse is also true. Those in the humanities do not want anything to do with quantitative methods. We should start thinking outside the box. In my hybrid e-learning study, I had to use qualitative methods in order to generate quantitative data for multilevel statistical analysis. A lot of humility is required, not only when embracing both approaches, but also when doing research in the social context of the problem.

Research is a very expensive venture. In this study, without Sida financial support, the study would not have been possible. We are very grateful to the Swedish Government and people. World Bank and other developed countries have now realized that higher education is important for development. Countries like Uganda have started putting emphasis on science, technology and innovations. It will be good if such countries continue to support applied action research by universities. The research should be not only demand-driven but it must be carried out in the context of the problem (either in industry or in the community/society).

ICTs are recommended to be mainstreamed by developing countries when attempting to achieve the Millennium Development Goals. The only progressive ICT that has been instrumental in creating the knowledge society is the Internet. However, for transformation of societies so that they can leap frog into the knowledge economy, broadband internet must be used. Governments must do everything possible to make broadband widely accessible to people. VSAT Internet is not sustainable in rural Uganda. Fibre optic backbone in Uganda should be laid with some urgency. Broadband will be required to support mass science and technology education of the even increasing population.

6.9 Recommendations

From this study it is necessary to make the following recommendations:

- It is evident that teachers who are either holders of diploma in education or 1. Bachelors in education (BED) cannot teach at A-Level. Such teachers are good in teaching methods but very inadequate in knowledge of the subject matter. Many such teachers were found to be teaching at A_Level in Muni and Ediofe due to shortage of qualified teachers. The coverage of the topics by such teachers is shallow and does not go deep enough to meet the requirements of the examination body, UNEB. Both Muni and Ediofe have very few science students. The cohort in the study consisted of 12 students of Ediofe and 7 students of Muni taking Physics. For Mathematics, Ediofe had 11 students and Muni had only ten 10. This is well below the standard requirement by the Ministry of Education and Sports (MOES) that a class should have 40 students. The fact that those few students cannot be taught well enough so that they pass their examinations should raise questions about the teachers. A-Level classes must be handled by graduates with Post Graduate Diploma in Education. The Ministry of Education and Sports should provide qualified A-Level teachers in secondary schools. The then qualified Physics teacher of Ediofe, though he also doubled as the Deputy Head teacher of the school, was very helpful in the project. He has since been promoted to head another secondary school. There was no such scaffolding of students of Mathematics because there was no qualified Mathematics teacher, either in Ediofe or in Muni. Hybrid e-learning helped the students but the effect would have been much better if the face-to-face teaching was handled by qualified teachers.
- There was no evidence in both rural schools that the inspectorate role by 2. the Education Standards Agency (ESA) of the MOES was being done. Both schools were found operating without the curriculum, examination syllabus, teaching syllabus, schemes of work, lesson plans, science practical manuals and some other teaching aids like dissection kits for A-Level Biology students. Subject teachers dodge classes and do not appear for their lessons. Teachers only shallowly cover one third of the syllabus and present students for UNEB examinations. In 2006 students of Muni did only three Physics practical lessons instead of 30 recommended by the syllabus (one practical session per week during the school term). In Muni teachers beat students yet corporal punishment of students was abolished in all schools in Uganda by the MOES. Some teachers abuse alcohol and even come to teach under the influence of alcohol. There is absolutely no evidence that the schools were supervised. It is recommended that the ESA should be strengthened to carry out its functions of inspection of schools.
- 3. To improve Science and Mathematics performance in Uganda, the MOES has been carrying out in-service training of secondary school teachers,

building and equipping laboratories and libraries, repairing the existing laboratories and libraries. All these are very expensive ventures and only a few schools benefit every year. It will take many years before all the schools get qualified teachers, laboratories and libraries. Those limited physical structures justify the many school dropouts from one level of education to another since the facilities will never be enough. The numbers of students requiring to progress with education increase exponentially. However, the rate of increase of facilities is linear leading to an even increasing gap that will never be closed. The education system should be opened up. It is recommended that the MOES should consider introducing hybrid e-learning in schools as a way of supplementing its efforts in improving science and Mathematics education in Uganda. E-learning policy needs to be developed and implemented in schools.

- 4. This study was done in the context of the problem; it was a problem driven study. It was not the traditional way of doing research by the academia. Many stakeholders participated in the study as co-actors: students, teachers, drivers, Non-Governmental Organisations like SchoolNet Uganda, collaborating secondary schools like Makerere College School, Swedish collaborating institutions, Makerere University's Faculty of Technology, Arua District Local Government, Internet Service Providers like AFSAT, MOES autonomous institutions like UNEB and NCDC. This made the study transdisciplinary. It is evident that knowledge production also takes place in the context of application, not in universities only. Makerere University's research policy needs to be amended to acknowledge the presence of mode 2 approach to knowledge generation. Basic and Applied Research methods are inadequate when carrying out research in the context of the problem. There is an urgent need for universities like Makerere to embrace Action Research.
- 5. At the beginning of the study, there was a need to design, host and maintain a website for the research project for two years. The cheapest quotation that was submitted was 3000 USD by a commercial webpage design, maintenance and webhosting company in Uganda. The Swedish collaborating institution identified an open source platform, the Mambo, and a webhosting provider, *b-one.net*, to host the project website. The annual cost that is being paid is 47 USD. Makerere University uses a downgraded Blackboard as an e-learning platform. The cost of the license was 10,320 USD and annually they charge 20% more. When many students will start using the platform, it is common for the company to charge 100 USD per user. The University does not have money to sustain this platform. Another software problem was encountered when needed to do multilevel data analysis. All the software platforms available on the market were commercial ones. The common platforms costs per user were MLwiN (900 USD), HLM 425 USD, STATA 1,750 USD and SPSS 639 USD. For upgrade to a newer

version, 180 USD was required. For use by institutions like Makerere, 100 USD was charged per user. These costs were outrageous for poor, rural communities. Manual analysis of the data was done in this study with support from MS Office Excel. Uganda should recognise that commercial software are not affordable by developing economies. Uganda has an ICT Policy, which does not talk about software issues. It is recommended that this National document should be amended to specifically say Uganda is an open-source country. The country cannot afford the expensive proprietary software platforms.

- 6. The experience gained in this study shows that for rural projects to succeed, the communities must own the process. They should appear to drive the process and own it. There must be no hierarchy, all stakeholders are equal and are co-actors. The Rural Communications Development Policy, which gives subsidies to private business to roll out ICT services to rural areas may not be cost effective. Handling the poorest of the poor cannot be driven by market forces. Private individuals invest where they will get returns on their investment. It is true that the policy helped to take ICT services to rural areas. But the target group, the poorest of the poor, appear to have not benefitted from the policy.
- 7. While triple helix alliances between Government, Academia and Industry result in open innovations and sustainability, maintaining such alliances offer a lot of challenges. The challenges should not be ignored; they must be addresses continuously.
- Action research leads to development of communities or societies. Developing countries like Uganda need to support research in science, technology and innovations. However, research is generally the mandate of universities. Governments need to increase funding for research in Universities.
- 9. While ICTs have led to the creation of the Information Society, the Internet led to the creation of the Knowledge Economy. Further more, it is broadband internet that is transforming the world further by creating the Competitive Knowledge Economy. Some countries have made access to broadband internet a human rights issue. In this study, VSAT broadband internet was found too expensive to use in rural areas. Fiber Optic cables are not going to be laid throughout the Uganda in the near future. CD-ROMs and DVDs can be very attractive alternatives to broadband internet. In this study we successfully used interactive CD ROMs for e-learning purposes. This should be adopted while introducing open education in Uganda.

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