

THE TRIPLE HELIX OF INNOVATION: TOWARDS A UNIVERSITY-LED DEVELOPMENT STRATEGY FOR AFRICA

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Abstract

In knowledge-based societies, the interaction among a Triple Helix of university-industry-government is the source of innovation and development. Within a triple helix regime, university-government interactions can help jump-start the creation of firms if they are absent, or if present, expand their growth. The triple helix development model for Africa represents a radical departure from the conventional development models that has separated the three institutional spheres—higher education, industry and government and has consistently left out universities from development strategies and policies. The paper outlines the triple helix model of innovation and development and the emerging entrepreneurial university model as an academic reform strategy in the developing world, whereby higher education is refocused on issues of development, entrepreneurship and innovation.

Introduction

A Triple Helix of university-industry-government as relatively equal interdependent and interacting institutional spheres is increasingly becoming the requisite basis for innovation and development in a knowledge-based society. The emergence of a double helix of government-industry relations—a bi-institutional model of society—represents the great transformation of the 19th century. [1] On the one hand, the market became the organizing principle of social relations while, on the other, government moderated exchange relations to insure a living wage. The emergence of a triple helix of innovation, with the university as a key player, is the great transformation of the late 20th and early 21st century.

What is peripheral and what is central to innovation has been transformed in recent decades. Institutional transformation is reflected in the development of new legal frameworks that provide a basis for resolving conflicts that arise from the emergence of new modes of production. The Speenhamland Law of 1795 laid the basis for social relations in the UK's emerging industrial society, placing limits on exchange relationships in labour and guaranteeing workers a living wage. The US Bayh–Dole Act of 1980, and similar laws in Japan, Denmark and other countries, provided a framework for knowledge-based innovation, guaranteeing the sharing of intellectual property rights (IPRs) among academic inventors and their universities that provide the infrastructure for science-based innovation.

A stable regulatory framework for knowledge-based societies is a necessary but not sufficient condition for organizational innovation. The transformation of higher educational institutions, in particular universities, whether through internal or external impetuses from a teaching to a research and to an entrepreneurial university is a key element in creating a viable triple helix. Government actor's focus on innovation as well as traditional government activities is also a prerequisite. If knowledge-based industries are lacking; university-government interactions can help jump-start their creation. We argue that for Africa to integrate itself into the global knowledge economy, its development agenda should be organized around reinvigorated higher educational institutions that foster triple helix interactions.

1 The triple helix model

The triple helix model places a greater emphasis on interaction, external linkages and collaboration. It represents a radical departure from the conventional development models that has separated the three institutional spheres and has consistently left out universities from development strategies and policies. The new focus in bringing these three complementary but distinct spheres to work in tandem reflects an assisted linear model of science and innovation policy. [2] As a result, the triple helix system has altered the development field. It is now possible for technology transfer to play a residual role in support of the development of indigenous technological capability through learning by production, learning by adaptation and learning by innovation. [3] Conversely, the model can also be used to apply advanced science and technology in biotechnology and information technology to development problems in least developed countries.

The potential for future economic development increasingly lies within higher educational institutions, not only because of their research potential that may be underutilized, the so-called "European paradox", but also, because higher educational institutions have the students, an ever-renewing source of new ideas. Students may also be trained and encouraged to be entrepreneurs and be inspired to take up new roles as firm founders in a society lacking a strong entrepreneurial tradition, like Brazil, or add value to natural and raw agricultural product-dependent societies like Africa. New sources of economic growth are required to propel Africa and integrate it into the global knowledge economy. In current international competitive circumstances, innovation is too im-

portant to be left to the individual firm, or even a group of firms, the individual researcher or even a cross-national collaboration of researchers. Innovation has expanded from an internal process within and among firms to an activity that often occurs in other institutional spheres as well. It may take place within institutional spheres not traditionally thought of as having a direct role in innovation, such as, universities. Thus, while universities were in the past seen primarily as a source of human resources and knowledge, they are now being looked to for technology as well.

Many universities across the globe have developed the internal organizational capabilities to formally transfer technologies rather than relying solely on informal ties. Universities are also extending their teaching capabilities from educating individuals to shaping organizations in entrepreneurial education and incubation programs. Rather than only serving as a source of new ideas for existing firms universities are combining their research and teaching capabilities in new formats to become a source of new firm formation, especially in advanced areas of science and technology.

2 The triple helix transition

The triple helix begins from different starting points: separate institutional spheres that operate apart from each other or with one encompassing and directing the others. There is a global trend towards a mode in which the various spheres are autonomous but overlapping, not entirely distinct but not completely merged either. As this transformation takes place there is a shift from bilateral to trilateral interactions, from single and double helixes to university-industry-government joint projects. Examples include, the land grant universities in the US, the research schools program in Sweden, moving PhD students into firms to do their dissertations and firm researchers into universities to obtain higher degrees. In Ethiopia, efforts are underway to upgrade traditional industrial clusters by connecting them to foci of government funded research located at universities and research institutes that are encouraged to become more entrepreneurial. [4]

A typology of innovation systems incorporates various national perspectives and in triple helix terms, we can identify three such categories. First, there is a 'statist triple helix' in which the state encompasses academia and industry and directs the relations between them. Secondly, there is a 'laissez-faire triple helix', consisting of separate institutional spheres where government, university and industry operate apart from each other. In this model the university provides basic research and trained persons. It is expected that firms in an industry should operate completely apart from each other in competitive relationships, linked through the market. Government is limited to addressing problems that can be defined as market failures, with solutions that the private sector cannot or will not support. Thirdly, there is an 'interactive triple helix model', consisting of overlapping, yet relatively independent, institutional spheres.

Developed and developing countries both experiment with finding better mixes of functions and institutions in a triple helix of university-industry-government relations. For example, academia plays a role as a source of firm-formation and regional development in addition to its traditional role as a provider of trained persons and basic knowledge. Government helps to support the new developments through changes in the regulatory environment tax incentives and provision of public venture capital. Industry takes the role of the university in developing training and research, often at the same high level as universities.

Most countries and regions are presently trying to attain some form of the third variant of Triple Helix, with its university spin-off firms, trilateral initiatives for knowledge-based economic development and strategic alliances among firms (large and small, operating in different areas and with different levels of technology), government laboratories and academic research groups. These arrangements are often incentivized, but not controlled, by government, whether through new "rules of the game," direct or indirect financial assistance. Thus, a triple helix strategy may be the basis of an alternative development model, relevant to a world in transition from an industrial to a knowledge-based format.

3 Changes in the field of development

Traditional development models focused on entry into industrial society. The contemporary international development agenda has become more flexible, combining old and new concepts, with development moving from a dyadic interaction of centre-periphery to a development triad of 'state-market-community/civil society. Within this context, development is the result of collaboration and interaction between these sets of institutions. The three alternatives might then be labelled 'state-led', market-led' or 'community-led', indicating alternative models for development practice. [5]

Prior to these reformulations, attempts were made to create new forms of economic organization by employing existing resources in different ways. [6,7] In this Schumpeterian vision, the overall development of the economy is derived from the novel combination of resources. Central to this formulation was the fact that these economic and organizational developments were endowed with their own laws and principles. As a result, the development of the economy as a whole appeared like a phenomenon emerging on the basis of the interaction among its constitutive elements, but energized by specific actors. [8]

Schumpeter anchors his model of endogenous economic development around the entrepreneur. He uses this concept to explain that changes in social structure emerge from the actions and social interactions of the individual entrepreneurs living in distinct and yet interacting sectors of social life. [8] This is a viable model for an industrial society whose root structure of organization is the firm, and the resources bundled within it. However, as knowledge becomes a more critical resource for economic development, the boundaries of the firm must

become more porous to absorb innovation and the locus of entrepreneurship expanded. Thus, the most critical agent of development has become an entrepreneurial university that has economic development functions in addition to teaching and research as its core remit. [9]

While the Schumpeterian entrepreneur was the driving force in industrial society, we propose a university-led development model, in cooperation with other institutional spheres, in an increasingly knowledge-based society. Our thesis is that the traditional stages and evolutionary models of development may no longer be as relevant to innovation and economic growth as they were in the past. These models were abstracted from an increasingly superseded industrial era where socio-economic growth was premised on the abundance of arable land, natural resources and the availability of a large pool of labour. If African countries continue in this outdated trail, they may be left behind again.

We need to blend development strategies so that we do not end up exacerbating the already volatile situation that faces most Africans. As noted by Myrdal, production and distribution are interrelated within the same macro-system. [10] The assertion that the growth of production is a precondition for having more to distribute, which is still current in most discussions on planning in least developed countries, neglects this interrelation. [10] The successful planning and implementation of a bottom-up robust innovation and development strategy would work for greater equality, because the beneficiaries of development does not only know what they most need, but such collaborative ventures would enhance production.

While contending that the unhampered working of contemporary international market forces retarded the development of poor countries, [11] Myrdal sees the solution in education. He believed that education should be made into a people's movement, as it could be instrumental in creating effective pressure from below, which he considers to be largely missing, from most development reforms. That reforms aimed at re-organizing African higher educational institutions to take on an explicit economic mandate will promote greater equality is certain, but it is equally certain that they would increase productivity. [11]

A triple helix development model involves the transformation of higher educational institutions—the second academic revolution—that incorporates the classic ivory tower with a culture of entrepreneurship, innovation and technology transfer. In this transition, higher education and research institutions integrate into the production sector and into society in many ways. They develop capacities to translate research and education of youth into the formation of new organizations (firms, NGOs, cooperatives) that break the bounds of the traditional ivory tower university.

Heretofore, these boundaries were considered essential for the university to maintain its institutional integrity. However, since the growing interest in competence building will require expanded sources of support for development activities, there is the need for financial flexibility

and autonomy for African higher educational institutions. This demands the delineation of the development task of higher educational institutions, such as, universities beyond party politics to enable them deal conveniently with changes in political regimes. This autonomy and financial flexibility can only be realised in the absence of political interference and within transparent governance structures across higher educational institutions, the state and other institutional spheres.

The creation, dissemination and utilization of knowledge have become more directly involved in industrial production and governance. [12] The more explicit utilization of knowledge in industry and government, exemplified by the invention of the discipline of “knowledge management” and the growth of “intelligence” give knowledge producing institutions that have the organizational capacity to recombine old ideas, synthesize and conceive new ones a greater import. [13] Thus, we propose, a triple helix development model that takes into account novel institutional sources, in particular the university, as a source for recombination and innovation.

4 The triple helix development model

The triple helix model comprises three basic elements: (1) a more prominent role for the university in innovation, on a par with industry and government in a knowledge-based society; (2) a movement toward collaborative relationships among the three major institutional spheres in which innovation policy is increasingly an outcome of interactions among the spheres rather than a prescription from government or an internal development within industry; (3) in addition to fulfilling their traditional functions, each institutional sphere also “takes the role of the other” operating on a y axis of their new role as well as an x axis of their traditional function. Functional integration, as well as differentiation among institutions, takes place though interaction among the spheres.

Hybrid organizations are invented that embody elements of two or more institutional spheres to accomplish new goals. One example is the incubator facility that plays a dual role in the university, embodying industrial and academic elements. The incubator director serves as the translator between these two spheres, speaking the language of both spheres and having insider knowledge of each. The incubator facilitates linkages between start-up firms emanating from the university with sources of support in the industrial and governmental spheres. Thus, the university moves from playing a supporting role in training people and providing knowledge to other institutions to playing a leading role in creating an industrial penumbra around the university.

The ultimate source of knowledge-based economic development at the regional level resides in the ability to advance within and across technological paradigms. Irrespective of specific policy measures, it is increasingly realised that to promote innovation and socio-economic development require a strong interaction of institutions in order to enhance strategies for success. While successful instances are often reinterpreted to look like spontaneous developments, especially in *laissez faire*

societies, historical cases can always be traced to the active intervention of an individual or group. [14]

While MIT exemplifies a creative synthesis of academic research and educational formats it does so while playing an important role in the development of New England. [15] According to a report published by BankBoston, if the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced by the companies would make that nation the 24th largest economy in the world. The 4,000 MIT-related companies employ about 1.1 million people and have annual world sales of \$232 billion. That is roughly equal to a gross domestic product of \$116 billion, which at the time was a little less than the GDP of South Africa. [16]

The Regional Innovation Organizer (RIO) is the individual or group that takes the lead in conceptualizing a strategy for knowledge based growth and activating hitherto untapped resources to realize a shared vision. In the context of Africa, we foresee higher educational institutions as the answer to the absence of an innovation or development organizer, especially at the regional level. Re-orienting universities to take up this challenge may lead the way in assisting least developed countries to leapfrog stages of industrialization that are now disappearing in their countries of origin.

Critics have argued that that African university systems are academically oriented and industries are either non-existent or too weak and governments too bureaucratic to play respective roles envisaged by the triple helix model. However, as the development of the Internet in Zambia has revealed, [17] the problem does not lie with the model, but the fact that in Africa, these triple helix entities seem to be weak because their elements tend to work in isolation. The Zambian example has demonstrated that when these entities work together; they represent a significant force for change, similar to those found elsewhere. In the triple helix development context, each institutional sphere maintains its core identity as it interacts intensively with the others.

While the triple helix institutions at their nodes are active and recursively selective according to their own specific functions and institutional constraints, the network system of university-industry-government relations provides the transaction spaces needed by these development actors to translate policies into goals. As such, a triple helix development model cannot be reified into a neo-corporatist arrangement because of its implied emphasis on the dynamics of change and the appreciation of differences in opinion, position, and interests of their partners. [18]

A triple helix development model is based on the following trends within the shift from an industrial to a knowledge-based society:

- i. The transition from large scale physical technologies that mandate bureaucratic forms of organization to increasingly flexible smaller scale high technologies that can be utilized by smaller scale organizations

- ii. The emergence of polyvalent knowledge, in such areas as biotechnology, computer science and nanotechnology, that is at one and the same time theoretical and practical; patentable and publishable
- iii. The rise of an entrepreneurial university model that combines education and research with a culture of entrepreneurship, innovation and technology transfer.

5 From stage to spiral model in education

Some observers expect that least developed countries like Ethiopia need the chance to build dams and develop according to the same path as the advanced industrial countries did a century ago. The alternative thesis is that developing countries could pool their technology resources to take the lead in developing alternative energy technologies, such as photovoltaics, without disturbing the natural environment that is the basis for unique tourist industries such as the one that was emerging at 'Tis Abey' adjacent to the Blue Nile Falls. When a new power station reduced the falls to a trickle, destroying their natural beauty and the livelihoods of local tourist operators, this opportunity was lost. [19]

The form and content of education in the least developed world tends to mirror the prevailing concept of development underwritten mostly by donor agencies. Most African countries inherited a colonial educational system that was oriented to the developmental needs at the time. The goal of the educational system was to turn out clerks for the purchases of traditional agricultural export commodities, missionary proselytizing activities, and the colonial civil service. [20]

Technical education geared towards innovation and creativity was not on the colonial agenda. As Julius Nyerere wrote in 1967, colonial education was not designed to prepare young people for the service of the country. It was rather motivated by the desire to inculcate the values of the colonial society, and to train individuals for the service of the colonial state. [21] For instance, until 1987, Ghana, the first sub-Saharan country to attain political independence did not alter its educational structure modeled after the British system of education. This does not mean that there were no changes at all in the way education has been organized in Africa. New institutions have been founded; some built on research institutes specialized in local agricultural opportunities, and have developed curricula and research, expanding upon the original foundations.

In spite of this, the presumption especially in the educational policy formulations of the World Bank has been that mass primary and secondary education should precede the extensive development of tertiary educational capabilities. Nevertheless, the World Bank is increasingly aware of the role of universities in economic growth and innovation. Universities produce new scientific and technical knowledge through research and advanced training and serve as conduits for the transfer, adaptation, and dissemination of knowledge generated elsewhere in the world. [22] However, educational policies in Africa have overly focused on basic education, failing to take full advantage the potential of higher educational institutions as

a source for recombination and innovation.

Africa's educational policies underlie the stage model where growth is a discontinuous and dialectical process until a take-off stage of self-sustained advancement is reached. [23] This linear model whereby, the site of knowledge production is entirely separated from that of application [24] is outdated and no longer relevant to Africa's search for strategies to once again unleash the potential of its higher educational institutions like it did in training staffs for the colonial and post-colonial civil service. We call for a 'triple helix development' model that incorporates basic education with university-led economic development.

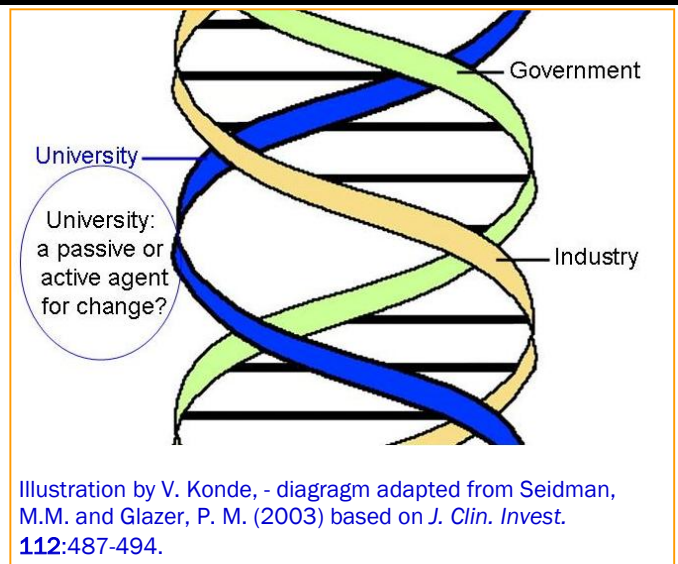
This spiral model of education, which is emerging as an academic reform strategy in a number of developing countries is refocusing undergraduate and graduate education on development. Some examples, in different directions, include the University for Development Studies in Ghana, the "Earth" university in Costa Rica and the Friburgo Campus of State University of Rio de Janeiro. Rather than developing undergraduate programmes focusing on existing industries, the Friburgo Campus of State University of Rio de Janeiro has developed a graduate research programme based on information technology (IT) that could be utilized to raise the level of a variety of local industries as well as create a new IT industry. The undergraduate programmes were projected to follow as a second step in the development of this university's full and extensive curriculum.

Thus, academic development leapfrogs the current stage of industrial development in order to seed new technologies and firms and upgrade existing ones. Academic reform may be used as a strategy to treat educational as well as research programmes and their combinations. This explains why the University for Development Studies (UDS) focuses its efforts on topics that will help address issues of rural poverty and community development, by including fieldwork projects as well as classroom training in its curriculum. [25] An even more radical project in Costa Rica involves both students and faculty in farming tasks so that they may inductively relate problems encountered in the field to course-work and provide a common framework for discussion.

6 Towards a university-led development for Africa

Utilizing African universities solely as a source for trained manpower may not be sufficient to attain the various developmental goals and ideals envisage in NEPAD and other development blueprints. There is the need for the reorganisation of Africa's development agenda to make it possible for higher educational institutions to play a leading role in the development process. The application of this concept may be extended to other levels of learning, such as colleges, research and technical institutes and polytechnic schools. [25]

First, universities need to undertake internal reform in partnership with various segments of society. Past experiences in other spheres of society and in regard to higher educational reforms done in isolation have failed in a large measure and increases inequality in terms of



access and content. [25] For instance, past initiatives were relatively secluded from each other with, for example, clusters focusing on business development, and centres on inter-disciplinary academic research. Today, there is a movement toward synthesis through the creation of a series of organizational mechanisms within and outside the university to enhance linkages of clusters with universities and to provide a platform for firm formation. [26]

Since African public universities have grown from about eight in 1960 to over one hundred in 2006, the time has come to increase their S&T transfer and innovation efforts in order to further Africa's socio-economic development. The formation of science-based firms from university research should be the centerpiece of this strategy. As the development of the Internet in Zambia, the establishments of the UDS in Ghana and efforts in Ethiopia to connect the traditional industrial clusters to foci of government funded research located at universities have shown, even poor universities can plan, adapt, innovate and commercialize emerging technologies to benefit their populations.

7 African universities and political regime change

In the early post-colonial era, most African countries, in particular the young and small university sector was invested with high national aspirations and public resources. The situation is very different today ranging from the reduction in the levels of public funding, incredibly expanded and diversified sector, to the questioning of the mission and mandate, the character, and the proper place of higher education sector, its institutions and their products in society. [27] The impact of these transformations were accelerated by economic and social changes specific to the African continent from the mid-1970s to the 1990s. These events include the virtual collapse of many national economies; the descent into autocratic military or civilian one-party or military governance systems in many countries, civil wars, and the bane of the HIV/AIDS pandemic. [27]

In addition to the historic handicaps of underdevelopment bequeathed by colonialism, these events blunted

the ability of African countries to take advantage of opportunities offered by globalisation, while exposing them to its negative effects. In relation to universities, the relevance of these developments was the general retreat of the state from social provisioning and the severe reductions in the level of resources for African higher education, [27] at the very time where academic research and knowledge has grown in social and commercial importance.

In most of Africa, relations between governments and universities have at times not been conceptualized in mutually beneficial terms. African governments and their universities have always had an uneasy and often antagonistic relationship. Most university heads or vice chancellors are appointed and controlled by their governments. Also, most governments and their functionaries consider universities as epicentres of criticism and political opposition. Rarely are higher education budgets determined through rational processes based on enrolments or strategic plans. [28] In fact, political interference in universities by governments has been a major drawback to university development and the development of nations on the continent. In an era of knowledge flows based on the utilization of university-industry-government partnerships to promote innovation, the interaction between universities and other development actors such as business, civil societal organisations and other constituencies are often non-existent in most of Africa.

Political interference in the affairs of higher educational institutions and the over dependence of African universities on their central governments to totally finance their budgets is a cause of this unnecessary confrontation and interference. The problem is exacerbated by the fact that when one regime is sensitive to the plight of the higher educational institutions by encouraging free interaction, the opposition political elements construe this as the politicization of the academy, and sought to punish the universities through budgetary squeeze and undue interference. As such, in order to enable African universities cope with political regime changes and lead the development of the continent, there is the need for political autonomy and financial flexibility. It should be pointed out that steps are being taken in some countries. For instance, in Ghana, the country's 1992 Constitution firmly stipulated that Vice-chancellors shall be appointed by university councils. [28] To consolidate this gain and reorganize African higher educational institutions to lead the continent's development agenda, there is the need to redefine the mission of African universities to include explicit economic development as found in other countries and regions.

Other possibilities for financial diversification include income generation through contract research, consultancy services, continuing educational programs, business enterprise, and fund raising through alumni associations. If financial diversification is to be successful, universities will have to become more efficient, goal-driven, innovative and enterprising. [28] To attain these ends, there is the need to establish an African

higher education 'endowment fund'. This fund must be managed by the Association of African Universities (AAU) and representative of donors to deal with corruption and ultimately the effects of possible regime changes. For a start, such international money transfer organisations like 'Western Union' and African governments who receive commission on these funds should contribute a certain percentage of remittances into this endowment fund. Secondly, African universities should form various consortiums to liaise with international accounting and data management firms such as Nielsen, Price Waterhouse Coopers, Ernst & Young, to conduct marketing surveys, audits, and reports for both local and multinational companies within their countries to raise funds.

In addition, there is the need for institutional linkages between African universities and higher educational institutions worldwide. Institutions benefit from a well-established flow of knowledge. Institutional linkages offer the best prospect to improve the exchange flow of knowledge, ideas and partners. It can enhance the flow of information and the availability and more rational use of resources. As problems become increasingly global in nature, this movement of ideas and people will greatly increase in significance. [29]

The time has come for a new development paradigm for Africa, a development that prioritizes knowledge as a basis for economic transformation. The emphasis on knowledge should be guided by the recognition that economic transformation is a process of continuous improvement of productive activities, enacted through business enterprises. In other words, government policy should be continuous improvement aimed at enhancing performance, starting with critical fields such as agriculture. [25] The promising aspect of this transformation is that most African countries have in place the key institutional components needed to make the transition towards being a player in the knowledge economy. The emphasis should, therefore, turn to the realignment of existing structures and the creation of new ones where they do not exist. [25]

8 Policy Implications

Innovation can no longer be assumed to take a conventional linear path, whether from research through development or from identification of market opportunities to product introduction. Instead, innovation increasingly occurs through a non-linear configuration, with multiple nodes and cross-over points much like the Internet. Innovation in this sense is more organizational rather than strictly technological, involving new configurations of interaction and the internal transformation of traditional institutions.

Innovation was expected to largely take place within industry with other institutional spheres playing only a limiting contributing role, government, for example, acting only when clear market failures could be identified. In countries that, to one degree or another, relied on central planning, it has become accepted that government programs have an important role to play, not only

from the national level, top-down, but also from the local level, bottom-up, often in collaboration with other organizations in civil society.

It is clear that innovation policy can no longer be conceived only as a “top-down” initiative of national government but should also be seen as the cumulative result of interaction among governments at various levels, business persons, academics, and NGOs comprising membership from all of these spheres. It is necessary to better understand these new innovation processes and to identify and encourage improvements in the way they work. It cannot be expected that entrepreneurs can always do this by themselves. When bottom-up initiatives that have proved successful, such as the incubator movement in Brazil that arose from the university and was then supported by municipal governments and industry associations, are reinforced by national policies and programs, perhaps the most dynamic and fruitful result is achieved.

Conclusion: Reorganizing African Universities

Enhancing an academic focus at a local university with possible future relevance to local economic development is now viewed as similar to traditional physical infrastructure development. When the problem is framed in terms of science-based regional development, an entrepreneurial university becomes a necessity. For us, a triple helix of university-industry-government interactions is especially crucial to developing organizational innovations that are necessary to reinvigorate Africa’s quest for innovation and development. The formation of science-based firms from the research of higher educational institutions should be the centrepiece of this quest.

In contrast to biological evolution, which arises from mutations and natural selection, social evolution occurs through ‘institution formation’ and conscious intervention. The triple helix provides a flexible framework to guide efforts, from different starting points, to achieve the common goal of knowledge-based economic and social development. The result is an interactive model, directed toward enhancing the interaction between human needs, research goals and resource providers; science, technology and society; university, industry and government.

The triple helix model provides a flexible framework for the transition of the African university from educating post-colonial elite to playing a more direct role in development, pointing the way for least developed countries to make the transition to a knowledge-based society. In order for African institutions of higher learning to play a dynamic role as leaders of innovation and development, there is the need for new institutional arrangements to be forged.

The potential for innovation and development in Africa, and elsewhere, resides in an entrepreneurial higher education sector, that is, ready and willing to take the lead in infusing knowledge, innovation, technology and enterprise into the entire society. Advice on science,

technology and innovation needs to reach policy makers. It is true that advisory structures differ across countries. However, all over the world, an active university and civil society are the key element that characterizes a fully functioning triple helix. In the statist model, civil society is often actively suppressed; in the laissez faire model, it is relatively inactive. As universities take up this new role in promoting innovation, they become transformed as well. The entrepreneurial university, embedded in a series of triple helix interactions, constitutes a new model of development.

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E-LEARNING: MAKE IT AS SIMPLE AS POSSIBLE, BUT NOT SIMPLER

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Abstract

This article summarizes our experiences trying to keep the instruction of computer sciences simple in an environment that is anything but simple. An analysis of the factors that contribute to the course's success shows that it is not the application of technology in various forms that is responsible but a careful instructional design based on sound pedagogical principles.

We developed course material that combines problem-based learning with e-learning to raise the motivation of natural science students taking an introductory information and communication technology class and to accommodate large classes

Introduction

Even though the amount of literature on e-learning is more than sufficient it is still difficult for the inexperienced to see the benefits of this educational technology or notice which pitfalls to watch out for when using computers to aid teaching. Reports such as 'The Future of Online Teaching and Learning in Higher Education' [1] make for interesting reading but are of little concrete help to someone faced with the challenge of establishing an online course.

This article summarizes the author's experiences over eight years of designing and employing e-learning classes for ICT and computer programming courses for natural science and civil engineering students at ETH Zurich. About 1000 ETH students complete these courses every year in a blended learning environment.

The materials we developed are also used complete or in part at other schools, and with the generous support of the North-South Center of ETH Zurich we are now translating the contents of the ICT course into English so that it can be used at a new research university in Zambia.

The observations I report here come not only from my work as an instructor, but reflect experiences I had during my four years as Head of Education of the Department of Computer Science. They also result from the numerous contacts I made while peer-reviewing the bachelor programs in computer science of many universities of applied science in Switzerland.

These contacts made it clear that in the context of e-learning it is particularly important for instructors to realize that they are exposed to many forces that result from priorities set and compromises made by those responsible for the educational system in which they have to function as teachers. The EDUCAUSE Current

Issues Survey Report [2] summarizes some of these priorities. This survey, now in its eighth year, asks campus information technology leaders to rate the most critical IT challenges facing them, their campuses, and/or their systems.

Having said this, I begin this review with a sketch of the bigger picture before discussing the reasoning behind the design of our e-learning courses.

1 Stakeholders of an educational system

The history of e-learning goes back to the early sixties and the debate about how to use computers in schools has not stopped since. Whereas in the early days the field only attracted those interested in learning theories or in the commercial potential of computer-supported teaching, it is nowadays a topic with a life of its own, affecting almost everybody and particularly those involved in education. So why not first contemplate who the major players with a stake in e-learning are?

The ultimate stakeholder of a country's educational system is its *society*, represented officially by members of its *political body*. Responsibility at the operational level rests with the individual *school administration* which oversees its degree programs, each managed by a *program director*. The actual teaching is the domain of the *lecturers* and the *students*, possibly supported by *teaching assistants*. Thus one can readily identify seven levels of stakeholders, each with different responsibilities, their own expectations and consequently unique ideas about e-learning. It might be interesting therefore to wonder who takes the initiative for e-learning and how the others are affected by it.

1.1 Society

The interaction between society and technology has never been easy; it is mostly unpredictable and can be difficult to control. This point is clearly illustrated in the April 2007 issue of the ATDF Journal [3] where Victor Konde argues that the type of policies which a nation adopts to guarantee benefits from Information and Communication Technologies (ICT) can have profound consequences on the country's development. The situation with societies is also frequently ambiguous in that its individual members need not necessarily share the opinion the society expresses as a whole. For example, even though 20 years ago in Switzerland most would have agreed that computers affect everybody's life in one way or another, many individuals would not have seen the need to acquire the competences required to take advantage of this technology.

Even when Switzerland, together with many other so-