Implementation of E-learning in Higher Education Institutions in Low Bandwidth Environment: A Blended Learning Approach

Nazir Ahmad Suhail, Ezra K Mugisa

Higher Education around the world is becoming networked and fundamental changes are taking place in Higher Education Institutions. There is no geographical isolation at the university or college level. When Higher Education Institutions are in the process of implementation of e-learning, a number of factors come into play. Some factors are about the technology, others about the prospective users, still others about the local context of use and the associated costs. On the other hand there are many aspects of the socio-economic and technological environment taken for granted in developed countries that need to be explicitly addressed during technological transformation in developing countries. These include; among other things, connectivity (low bandwidth) and accessibility, inadequate telecommunications infrastructure and lack of reliable power supply. This paper reviews various factors and processes with an emphasis on university settings and after analyzing, synthesizing and making a comparative study of the frameworks and models, the paper proposes a gradual transition model for implementation of e-learning in Higher Education Institutions in Least developed countries followed by a comprehensive framework adaptable in low bandwidth environment using a blended learning approach. Implementation process of the framework is also explained.

Introduction

The growth in Internet has brought changes in all walks of life including the education sector through e-learning. The globalization of Higher Education is increasing rapidly; students attend courses of study from all over the world, employees work and study globally. Seufert (Seufert 2000) explains, “Due to the inter-activity and ubiquity of the Internet, learning is possible without space and time barriers. The long-term implications are a worldwide network and a real market place for university and college level education. This will expand naturally into vocational and adult training as well and Education might become a major export factor between countries”.
When Higher Education Institutions start the process of implementation of e-learning, a number of factors come into play; “Some factors are about the technology, others about the prospective users, still others about the local context of use and the associated costs” (Wilson et al 2002). Alexander (Alexander 2001) views that successful e-learning takes place within a complex system composed of many inter-related factors. On the other hand (uys et al 2004) pointed out that during technological transformation in the developing countries; there are many aspects of the socio-economic and technological environment taken for granted in developed countries that need to be explicitly addressed. These include among other things; connectivity (low bandwidth) and accessibility, inadequate telecommunications infrastructure, and lack of reliable power supply.

This paper reviews various factors and processes with an emphasis on university settings and after analyzing, synthesizing and making a comparative study of the frameworks and models, the paper proposes a gradual transition model for implementation of e-learning in Higher Education Institutions in Least Developed Countries, followed by a comprehensive framework adaptable in low bandwidth environment, using blended learning approach, which addresses the issues associated with developing countries.

Global Trend
According to the report (Norman et al 2003), the global market for e-learning in various parts of the world which include; USA, Europe, Asia, and Africa is significant and increasing. It is reported that e-learning is one of the fastest growing sectors in the U.S and Europe education and training market with the total dollar value of all e-learning products and services projected to reach dollars 40.2 billion and 6 billion respectively in 2005. By giving the details of e-learning developments which have taken place in Asia and Africa, the report concludes that more than 120 universities in Japan have installed a communications satellite system for organizing lectures, seminars, and meetings, while developing countries are also making extensive use of distance learning.

Statement of the Problem
Least Developed Countries (LDCs) fall under the category of low bandwidth environment, where the average bandwidth available to a user is much lower than that in the developed world (aidworld 2006) and average university pays 50 times more for their bandwidth than their counterparts in other parts of the world (Steiner et al 2005). Due to inadequate infrastructure and scarce resources, the Higher Education Institutions(HEIs) in these countries do not have the capacity to meet the growing demand of higher education, which is expanding exponentially (Goddard1998) throughout the world. Volery et al (Volery et al 2000) hold that capacity constraints and resource limitations can be overcome through the implementation of e-learning and creating a new opportunity to satisfy this growing demand in the mature student market.
Claudia (Claudia 2002) argues that all these obstacles together with high priced services, are obstacles which can be called a ‘vicious circle’ to Internet penetration in the country, and this vicious circle cannot be broken without decisive intervention of one or more of the above mentioned constraints. Claudia views International IP connectivity as a critical barrier to Internet, which is possibility for a user on an electronic network to communicate with other networks, and it precedes access to and use of Internet. He further adds that the width of this digital route is “bandwidth”, i.e. the maximum amount of information (bit/sec) that can be transmitted along a channel (data transmission rate).

According to (infobrief 2003), by recognizing that bandwidth is a valuable institutional asset that needs to be managed, and conserved, this approach puts emphasis on how to explore ways to control and manage the many bandwidth hungry Internet applications, uses, and practices. However, as implementation of e-learning in HE institutions leads to fundamental shift in learning styles (Singh et al 2001), in that regards, (Bates 2000) argues that for the universities to initiate a change in their methods of teaching, an over reaching framework is needed to ensure that the use of technology needs are embedded within a wider strategy for teaching and learning. The existing frameworks do not address the issue of Internet infrastructure, among other limitations. Therefore for successful transformation, (Uys et al 2004) suggest that e-Learning needs to be implemented within a strategically developed framework based on a clear and unified vision and a central educational rationale, hence a need for a comprehensive and strategic framework with particular emphasis on bandwidth management by the HE institutions in low bandwidth environment which can facilitate the fundamental shift from once for life learning model to life long learning style.

**Existing E-learning Frameworks**

A number of Frameworks and models exist for implementation of e-learning in higher education. But they are not static rather they are dynamic and have evolved from classroom based teaching towards models that incorporate technology and pedagogical issues. Elmarie (Elmarie 2003) noted that, “While the first e-learning models emphasised the role of the technology in providing content, delivery and electronic services, more recent models focus on pedagogical issues”.

Some of the existing E-Learning frameworks and models are listed below:

**Framework for Rutgers University (USA)**

According to authors Triveni et al (Triveni et al 2003) ‘The Learning Framework Study Group’ recommended the framework proposed by Khan (Khan 2001) of The George Washington University for Rutgers University Libraries. Khan’s framework as shown in Figure1 has 8 dimensions: Institutional, Pedagogical, Technological, Interface design, Evaluation, Management, Resource support, and Ethical considerations. Table1 briefly explains the dimensions of the framework. Khan’s frame is located in Khan’s publications, namely, B.H.Khan (Ed.), Web-based training (pp.355-364; Englewood Cliffs,NJ: Educational technology Publications, which is translated
into many languages of the world and it is very popular especially in developed countries. Barry (Barry 2002) noted that, “Various issues within the eight dimensions of the framework were found to be useful in several studies that were conducted to review e-learning programs resources and tools”.

**Fig 1: An e-learning framework: Adapted from (Khan 2001)**

![An e-learning framework: Adapted from (Khan 2001)](image)

**Table 1: An e-learning framework: Adapted from (Khan 2001)**

<table>
<thead>
<tr>
<th>No</th>
<th>Dimension</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Institutional</td>
<td>Institutional readiness, Institutional matters, Collaboration, Administrative matters, Organisational, Academic, Infrastructure availability, and Planning</td>
</tr>
<tr>
<td>2</td>
<td>Technological</td>
<td>Availability of Technology Infrastructure</td>
</tr>
<tr>
<td>3</td>
<td>Pedagogical</td>
<td>Teaching/Learning requirements, Content Management Systems</td>
</tr>
<tr>
<td>4</td>
<td>Resource Support</td>
<td>Online, Offline technical support</td>
</tr>
<tr>
<td>5</td>
<td>Evaluation</td>
<td>Assessment of learners, Instructions and programs</td>
</tr>
<tr>
<td>6</td>
<td>Interface Design</td>
<td>Overall look and feel of E-learning programs</td>
</tr>
<tr>
<td>7</td>
<td>Management</td>
<td>Maintenance of learning environment, Distribution of information</td>
</tr>
<tr>
<td>8</td>
<td>Ethical considerations</td>
<td>Social and Cultural diversity, Copyright and so on</td>
</tr>
</tbody>
</table>

Khan argues that this framework can be applied to e-learning of any scope. Each dimension has further sub dimensions and each of these are inter related, e.g., after handling all matters concerning staff, students, and planning in Institutional dimension, next step is to put in place the necessary technology to support the e-learning programs, followed by e-learning teaching requirements etc. Author believes that a meaningful e-learning environment can be created for a particular group, by putting each stake holder group (such as learner, instructor, support staff etc.) at the center of the framework and raising issues along the eight dimensions of the e-learning environment as shown in Figure 1.
Framework for Adaptation of Online Learning

The Framework for Adaptation of Online Learning was developed by Faridha (Faridha 2005). It is a modification of Bates (Bates 1997) ACTIONS model which has elements: Access (A), Cost (C), Technologies (T), Interactivity (I), Organization (O), Novelty (N), and Speed (S). Faridha grouped online learning issues into three categories; Educational, Managerial, and Technological.

Educational: This factor addresses the issues concerning; curriculum development, instructional design, and delivery.

Managerial: All organizational matters and constraints for implementation of online learning are looked at in this factor.

Technological: This factor handles issues like: access, integration, usability, and flexibility.

The LASO (Leadership, Academic and Student Ownership and Readiness) Model for Technological Transformation in Tertiary Education

The LASO Model for Technological Transformation in Tertiary Education is based upon major findings of the author Uys (Uys 2004) at his Doctoral research in New Zealand. The Model has the elements: Leadership, Academic, Student Ownership and Readiness, as shown in Figure 2. According to this model technological transformation occurs when leadership is integrated with academic and student ownership and readiness, whereas Leadership is achieved through mechanisms which define a clear vision for the transformation, providing incentives for the staff engaging in the change process and the creation of a strategic framework to guide the transformation. The author argues that the strategies such as; pilot projects, extensive training, establishing workgroups in every faculty/school, teams for courseware development should be used to achieve the Ownership and Readiness for change by both students and academic staff. A ragged line shown in the figure “signifies the complexities and dilemmas with which technological transformation is often associated”.

The LASO model is proposed for developed and developing environment. MacNaught et al (in Uys et al 2004) state, “The LASO model for technological transformation is one where management provides for the requisite vision, direction, organization, focus and control over the resources needed and thereby empowers the staff for action and ownership of the transformation”. The model also includes an inside-out dimension as it attempts to address the affective domain such as motivation of staff and students.
A Framework for Success

The Framework for Success was proposed by Jennifer (Jennifer 2005) and has five elements: Technology, Content, Administration and support, Communication, and Financial analysis.

**Technology:** There are two types of technologies; synchronous and asynchronous. Synchronous technologies involve real-time interaction between an instructor and learner and they are like a broadcast with a time and a “channel” (web URL) for tuning in, and include webcasts, webinars, and chats, which can be recorded and replayed, and the recordings would be considered as asynchronous. The author argues that it is necessary to make IT department a partner in the technology decision making process.

**Content:** Content can be developed internally or can be bought from vendors. Therefore organizations should decide as what content to buy vs. build internally.

**Administration and support:** Further to content development what follows is administration and student support. According to author, it is necessary for someone to be there full time for student support to receive queries, issue of identity cards, and to facilitate registration process etc.

**Communication:** Two factors are to be considered when communicating e-learning strategy to learners; change management and marketing communications.

**Financial analysis:** Much emphasis should be put on financial analysis, as this is the factor which determines sustainability of the e-learning program, and financial analysis should include all related costs including; cost of technology, authoring tools, course development, support, and administration.
The demand-driven learning model

The demand-driven learning model was developed in Canada by MacDonald et al. (MacDonald et al. 2001) as a collaborative effort between academics and experts from private and public industries. It emphasizes the three consumer (learner) demands: High quality content, Delivery, and Service. As shown in Figure 3, the superior structure has its components: (learners needs, learner motivation), (learning environment, program goals), pedagogical strategies, and (learner evaluation, learner convenience). Other components of superior structure are: (content, delivery, and service), which result into superior learning outcomes (lower cost of learner and employer, personal advantage of learner), with emphasis on ongoing program evaluation and continued adaptation and improvement.

Content: Content should have qualities like; authenticity, comprehensiveness, and should be research based.

Delivery: A web-based delivery is recommended which should have user-friendly interface with communication tools to support interactivity.

Service: Service should include; the provision of resources for e-learning, administrative and technical support.

Fig 3: The demand-driven learning model: Adapted from (MacDonald et al 2001)

Critique to Literature Review

In terms of key factors important commonalities are identified between existing frameworks and models listed above; they refer to, and suggest, similar factors. Some frameworks such as (Macdonald 2001) and (Faridha 2005) combine several
elements under one factor while others like (Jennifer 2005) and (Khan 2001)) refer to each of these areas as a key factor. In addition to that, it is noted is that some frameworks have a starting point whereas some other frameworks do not specifically point to a starting point when looking at e-learning implementation.

Finally, and more importantly, the reviewed literature reveals that the core factors; accessibility and connectivity (low bandwidth), irregular or non existent power supply, inadequate telecommunication infrastructure, high cost of hardware, software, economic conditions, and cultural issues, associated with implementation of e–learning in least developed countries, which fall under the category of low bandwidth environment and which need solution are not considered. Therefore, there is a need for a comprehensive framework which facilitates the implementation of e-learning systems within higher education in low bandwidth environment, addresses the above issues, and works as a road map for transformation of once for life learning style to life long learning model.

Proposed Gradual Transition Model for Implementation of e-learning in HE Institutions in LDCs

Implementation of e-learning technology in higher education provides a wide range of new opportunities for development by increasing flexibility in time and location of study (Ravenscroft 2001). Although e-learning has the potential to contribute in the educational advancement of developing countries, but the strategies and techniques of introducing it differ significantly than those used in developed countries (Ahmad 2004), due to different cultural and economic conditions. Therefore, to overcome such socio-economic and infrastructural constraints associated with these countries, a gradual phased transformation (Naidu et al 1996) from conventional face-to-face learning to e-learning is required in the context of university settings. In order to facilitate this gradual transition without compromising the quality of education provided by close classroom interaction, we propose a gradual transition model as shown in Figure 4. The model represents a continuum of educational technology integration into the various kinds of learning styles in higher education system. It originates from conventional face- to- face learning mode to the supplemental use of technology in the classroom, through blended or hybrid learning, to fully online distance learning environment, followed by Mobile learning (M-Learning) (Susan 2003).
In order to enter into the arena of e-learning, according to our proposed Transition Model, the first phase after Traditional face-to-face learning mode is Blended learning. Harvey (in Balarabe 2006) defines Blended learning as, “a mix of different types of training; Synchronous and Asynchronous components, Instructor-facilitated and Self-paced components, and e-learning and Traditional face to face learning”.

The next phase after blended learning is online learning or e-learning. There is no widely agreed upon definition of e-learning. However, (CTAL 2001) in a comprehensive sense, defines e-learning as, “Instruction and learning experiences that are delivered via electronic technology such as the Internet, audio- and video-tape, satellite broadcast, interactive TV, and CD-ROM. Web-based learning, computer-based learning, and virtual classrooms are some of the processes and applications used to distribute e-learning”. E-learning can be Synchronous learning, a real-time, instructor-led online learning in which all participants are logged on at the same time and communicate directly with each other or Asynchronous learning, self-paced, in which instructor and learner interact with a time delay (Webb et al 2004).

The last phase of the Model is Mobile learning or M-Learning. M-learning can be defined as “learning that is mediated by mobile devices such as mobile phones, Personal Data Assistants (PDAs), handhelds, wearable devices and laptops” (Doherty 2003). M-learning is useful for administration and organization in higher education (Wood 2003) and can be used to complement other teaching and learning methods or to replace them. Many people across the globe have access to these devices. On the other hand, currently, most developing countries do not have necessary infrastructure to support M-learning and it cannot be implemented as yet. Although, (Masters 2004) proposes that institutions within these developing countries should establish and commence mobile learning efforts as soon as possible.

**Proposed Comprehensive Blended learning Framework**

Our Proposed Framework is based on Khan’s (Khan 2001) Blended e-learning Framework having dimensions; Institutional, Pedagogical, Technological, Interface design, Resource support, Evaluation, Management and Ethical. Harvey (Harvey2003)
argues, “Organizations exploring strategies for effective learning and performance have to consider a variety of issues to ensure effective delivery of learning and thus a high return on investment, while Khan’s framework has capacity to serves as a guide to plan, develop, deliver, manage, and evaluate blended learning programs”. On the other hand, in this framework, many aspects of the socio-economic and technological environment such as connectivity (low bandwidth) and accessibility, inadequate telecommunications infrastructure, and lack of reliable power supply are taken for granted that need to be addressed during technological transformation in the context developing countries (Uys et al 2004).

In terms of factors, our proposed “Comprehensive Blended Learning Framework adaptable by the Higher Education Institutions in Low Bandwidth environment” as shown in Figure 5 is a modified form of Khan’s Blended learning framework. The proposed framework considers those issues and shows that constraints like; scarcity of resources and inadequate infrastructure, including insufficient bandwidth cannot be the barriers towards the process of e-learning implementation (IICCIT 2006).

The proposed framework has dimensions; Institutional, Infrastructure, Bandwidth, Cultural, Content Development and e-learning Tools, Management and Student Support, Communication, Access and Financial Analysis. All the dimensions are inter-related and are in sequence of logical order. According to the framework, first step is to handle Institutional matters and putting in place the necessary Infrastructure, addressing low bandwidth and cultural issues and overcoming other constraints., which is followed by Content Development & e-learning Tools and Management of blended learning programme & Student support dimensions. Next, the developed courses are put online and are communicated, which are accessed by on campus and off campus students. The last dimension of the framework is Financial Analysis-the sustainability criteria of the technology transformation. The outcome of the implementation of the framework is increased enrolment with no extra lecture rooms for HE institutions and Flexible, Quality Higher Education at affordable cost for students.

Fig 5. Proposed Comprehensive Blended learning Framework adaptable in Low Bandwidth environment
**Institutional:** The Institutional dimension addresses issues concerning; organizational readiness, a vision for e-learning at the institution & development of technology development plan, formation of steering committee, human and financial resource allocation, staff and student affairs (khan 2001). Recruitment, library services, collaboration with other institutions, maintenance of infrastructure, and general administration, student ownership, copy right and learners needs, offering each trainee the learning delivery mode independently as well as in a blended program, are also part of the Institutional dimension.

**Infrastructure:** After the institutional vision for implementation of e-learning in their program offerings, readiness, and resource allocation, and handling other administrative matters, the next step is to put in place the necessary Technology Infrastructure. The term “infrastructure” according to (Blinco et al 2004), is highly contextual in its meaning and in e-learning contexts, “e-learning infrastructure”, “technical infrastructure”, and “ICT infrastructure” all convey a range of meanings. The basic requirement for implementation of e-learning is the availability of regular power supply, computers, telecommunication infrastructure, reliable Internet connection, and bandwidth. The necessary Technology Infrastructure also includes; high-speed access to the university network and the Web, including access from off-campus, provision of appropriate classroom technologies, and student computing abilities. Bates (Bates 1997) argues that, “While technology infrastructure strategy is absolutely essential, it is often the first and sometimes the only strategy adopted by universities build it and they will come”.

**Bandwidth:** Bandwidth is part of necessary infrastructure for implementation of e-learning. But in LDCs the insufficient bandwidth that supports the educational needs of students and university, adversely affect delivery and teaching using e-Learning technologies that rely entirely on a high-speed campus backbone (Claudia 2002). In the implementation of e-learning process bandwidth is required by the institution for the development of e-learning course materials (content development), and by the learners who access those materials. Institutional bandwidth can be conserved through Bandwidth optimization. From the perspective of bandwidth, all media are not created equal. Asynchronous e-learning uses web based learning modules but does not support real time interaction between the instructor and the students. Synchronous e-learning consists of on-line real-time lectures, which typically have to be joined by students at the time of their delivery. Additional asynchronous functions typically support the learning environment. Most demanding in terms of bandwidth are forms of collaborative e-learning in which students have to interact continuously to solve problems or engage in other learning activities. Table2 below illustrates that only certain forms of e-learning require broadband support.
Table 2: Broad band requirement for e-learning: Adapted from (Bauer et al 2002)

<table>
<thead>
<tr>
<th>Application</th>
<th>Network demand</th>
<th>Complementary Functions and Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asynchronous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Based Training, Multimedia</td>
<td>POTS</td>
<td>E-mail Automatic upload of Educational materials</td>
</tr>
<tr>
<td>Database Support System</td>
<td>ISDN</td>
<td></td>
</tr>
<tr>
<td>Synchronous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote Lecture Room, Interactive</td>
<td>Up to 6 ISDN channels, ATM, Internet protocol stack</td>
<td>Bulletin board, videoconference systems, e-mail, chat room, file exchange tool</td>
</tr>
<tr>
<td>Home Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote Seminars</td>
<td>Up to 6 ISDN channels, ATM, Internet protocol stack</td>
<td>Bulletin board, videoconference systems, e-mail, chat room, file exchange tool</td>
</tr>
<tr>
<td>Interactive Seminars</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Text and simple graphics can be downloaded quickly even in low bandwidth environment, whereas complex media require more bandwidth (Bruce 2001), which can be acquired through bandwidth optimization; exploring and controlling bandwidth hungry applications, filtering undesirable traffic from reaching backbone. Other possible solutions according to (ATICS 2004) are; formation of bandwidth consortium-which could cost half the cost of bandwidth, management of centralized network and technical capacity, improved regulatory policies regarding educational bandwidth. Although, bringing Internet access into the remote rural village in a least developed country is still a challenge different than optimizing it at a university, in its library, labs, and offices, or on the desktops of government or business officials in a capital city (David 2004).
Cultural: Implementation of e-learning changes the perception of teaching and learning, by providing entirely new educational culture (Karen 2006). It reconstitutes the roles for faculty members such that faculty members become e-Learning content developers, instructors, content experts, instructional designers, graphic artists, media producers, and programmers. Some incentives should be put in place to reward them.

Cultural change is a complex and one of the biggest challenging subjects in any medium and most particularly in the context of LCDs. People fear from the technology. Cultural awareness extends to appropriate design that takes into account the different learning styles. For example design that presents characters, thoughts, and speech in both audio and text format can address: accessibility to technology, different learning styles, and consideration of language needs for non native speakers of the language being used, and for native speakers with unfamiliar accent.

Another important factor to be considered in any training product design is learner motivation.

Content Development and e-learning Tools: Once the technology infrastructure is in place, the faculties interested in offering their programs in blended learning, are to develop and design the courses according to learners needs, offering each trainee the learning delivery mode independently as well as in a blended program (Harvey 2003).

E-learning content development is a team work (John 2004). It includes: Instructional designers, Subject matter experts, Software developers, Graphic designers, Project managers, Database specialists, and Translators. Multimedia specialists, Distance learning specialists, professors, and instructors are also part of the content development team. Other team members are: Information security and privacy experts and Legal advisers.

Developed courses are to be put on line which can be accessed both by on campus and off campus students. Other requirements, according to (John 2004) include: Virtual Learning Environment (VLE), use of research facilities and resources, video and audio streaming, web conferencing, Computer Assisted Assessment (CAA). Learning Management System (LMS) and Learning Content Management System (LCMS) are also part of the e-learning tools. LMS is a program that manages the administration of training, typically includes functionality for course catalogues, launching courses, registering students, tracking student progress and assessments, and (LCMS) is a web-based administration program that facilitates the creation, storage and delivery of unique learning objects, as well the management of students, rosters, and assessment.

Proposed Two level Bandwidth Optimization Model

Figure 6 below shows Two level Bandwidth Optimization Model; at first level optimization of available institutional bandwidth by controlling bandwidth hungry applications and uses and at second level by optimizing media performance.
Optimizing Media performance

There are two main ways to improve the course’s performance: media optimization and streaming. The content that is presented in a continuous stream as the file downloads is referred as Streaming media. The streamed file starts playing before it has entirely downloaded. It is an effective way to deliver bandwidth-intensive content without making the user waiting. The streaming technologies can be used to reduce the bandwidth, but the rule of authoring is to make the courses small, which is called optimization. To optimize various media types effectively, techniques used, according to (Bruce 2001) are the following:

**Text**: Text files are small and perform well at low bandwidth, users can search for specific words, and content can be updated easily. Using anti-aliased text avoids having to create display text as a graphics file, which can make the course size much larger.

**Graphics**: Graphics are optimized by modifying file attributes, such as decreasing the resolution, size, and number of colours. Web graphics should have a bitmap resolution of 72 pixels per inch. Using graphics saved at a higher resolution will make the file unnecessarily large. The size of imported graphics should not be changed directly in an authoring tool and large graphics can be resized in an image-editing application.

**Animation**: The animation file size is dependent on the size and file type of the graphics being animated. Techniques for optimizing animations are similar to those for optimizing graphics.
Audio: Large audio files can be optimized for efficient playback. Audio can be optimized by balancing sound quality and file size while musical audios by use of a short file that loops rather than one long audio track. Several files can be looped to play throughout your piece. Because Mono audio files are significantly smaller than stereo audio files, therefore files should be saved as mono unless it is necessary to use stereo audio.

Video: High bandwidth is required to download a video. Three standard digital video formats are: QuickTime, Video for Windows, and MPEG. Streaming video format, such as Real Video, requires a special server. Video files tend to be large and are not appropriate for delivery on modem connections—low bandwidth. Users can turn on bandwidth detection to automatically receive video at the highest quality their bandwidth supports. Video is captured, edited, and optimized in video editors such as Adobe Premiere. If video is too bandwidth intensive, it can be substituted with still graphics and audio, which will considerably decrease the size of your course. As Flash files are considerably smaller, substituting animation can also make downloading more efficient.

A careful decision should be made by the users when viewing various types of media, as text and simple graphics can be downloaded even at any available bandwidth. The chart below illustrates the file size required to present approximately one minute of media.

Fig 7: File size requirement for presenting one minute media: Adapted from (Bruce 2001)

Authoring guidelines
Following are some of the techniques to deliver low-bandwidth courses.

Interface design: It should be noted that a clean and simple interface design can make courses more compact. By using the authoring program’s drawing tools, create large blocks of colour rather than importing bitmaps. The graphics
without gradients compress better than heavily shaded graphics. Moreover, only those graphics should be used that are necessary for learner comprehension. For self-paced training, CD-ROM and DVD are usually created on 800 x 600 pixel screen resolution but online courses require a smaller screen resolution that will download quickly.

**Status indicators:** Status indicators should be added to inform users when they are waiting for files to download. Progress bars will show how quickly a file is downloading. Loader movies presented in a very small window, present a short introduction or entertaining animation that can hold the user’s attention while files are downloading. The Loader movie can be a lightweight main menu that loads other portions of the course.

**Management and student support:** The Management dimension deals with issues related to the management of a blended learning program, such as infrastructure and logistics to manage multiple delivery types. Harvey (Harvey2003) argues that delivering a blended learning program is more work than delivering the entire course in one delivery type. The management dimension also addresses issues like registration and notification, and scheduling of the different elements of the blend.

**Communication:** After putting the courses online. There are some factors to consider in communicating e-learning strategy to your learners which include: Real time communication, change management and marketing communications (Jennifer 2005). Due to reduced bandwidth, which is the information carrying capacity of a communication channel, real-time communication is a bit problematic issue for LDCs. However, universities can collaborate, form partnership among them and buy high bandwidth in order to achieve this benefit which is very important. Universities should use both print and electronic media to publicize their online courses. Some resistance in the beginning is expected.

**Access:** In order to implement e-learning in the universities, students are required to have access to computers and Internet, whereas access to computer technology is a major issue, particularly in developing countries. In these countries many students cannot afford to purchase computers and network access. Those who have computers have machines that are not suitable for multimedia or Internet access. Several strategies can be used to provide support for student access to computers, like providing computer labs on campus for students. Although, “It is a useful start-up strategy, but it becomes unsustainable in the long run as the primary source of student support but relying on computer labs for access has some drawbacks. For example, as the need to use computers for learning increases, either capital investment costs get out of control, or students’ lining up for access reaches unacceptable levels. Secondly, with the technological change, computers in labs can get outdated (Bates 1997). Other strategies to increase the accessibility of computers and networks for learners are the development of government-funded
educational networks, equipped with advanced technologies including generators to help learners who stay in remote areas with non-existent or irregular power supply.

More important, the main advantage of e-learning technology is flexibility- a learner can choose where, when and how to learn but students to access learning from a specific place, often at a specific time, if they have to book, thus removing one of the main advantages of using technology- its flexibility. However, in the long run the most flexible and most cost-effective approach is to encourage students to provide their own computers and Internet access. Governments should provide loans to the students.

**Financial Analysis:** The return-on-investment is the most important factor, which determines whether e-learning program receives the investment it needs to succeed and grow. The financial analysis should include: Costs for technology, authoring tools, course development, support, and administration (Jennifer 2005).

**Implementation of the Proposed Framework**

The implementation process of the proposed framework include: Strategic target, Need analysis, Plan and Design, and Implement and Improve (Ingrid 2003).

**Strategic target:** Collis (Collis2002) analyzed the most frequent objectives of ICT policies in higher education institutions, among which he found objectives regarding pedagogical (enhancing quality of learning), economical (e.g. enhancing cost-effectiveness, generating institutional income), business (e.g. enhancing competitiveness, enhancing status and reputation of the institution) and organizational (e.g. enhancing flexibility) aspects.

**Need analysis:** In order to realize the strategic approach, it is important to know the specific change needs of the organization. Needs assessment program should also be concentrated on identification of possible courses to be delivered through e-learning framework based on market demand.

**Planning and Designing:** In addition to planning the technical, financial and organizational infrastructure, the human factor is a critical success factor. An innovation will only be adopted, if the key stakeholders are motivated and competent to manage the change. Motivation and ability have to be fostered on the individual, department and the board level (Ford 1996). Following are some of the planning considerations to be taken in this phase: learning and teaching (identify e-Learning scenarios for university teaching culture, establish a stakeholder-management), technology (building technical architecture e.g. selection of central LMS, support for standard authoring tools, provide networked workstations for staff and students).

**Implement and Improve:** The program based on the results of the needs assessments and satisfying the local constraints should be designed. The course design included the following components: On line components would be applied in limited extent
due to inadequate accessibility, course material would be presented on CD and used for self-study, e-mail would be used for disseminating information about the course, assignment, course upgrades. It would be mandatory for all participants to have an e-mail address, all materials and information would be available online as well as on CD, Discussion boards would be available for student communication, Facilities for communication with the instructors would be available and especial attention would be provided to ensure interaction and communication. Important aspect in the implementation phase is the identification and handling of resistance (Brake 2000). This research is still going on.

Conclusion
Many factors point the way to successful implementation of e-learning in the universities in low bandwidth environment. Learning those factors—both external and internal and how those factors work in the context of inadequate infrastructure will be essential to a sound strategy. This paper has provided a comprehensive review of e-learning strategy implementation literature and, based on this, proposed a blended learning comprehensive framework, adaptable in low bandwidth environment. In order to facilitate a gradual transition from conventional classroom-based learning to e-learning without compromising the quality of education provided by close classroom interaction, gradual transition model is also proposed. The Implementation process of the framework is also highlighted.

This framework is of high practical importance and usefulness. Its implementation is a means of reducing the cost of higher education, enhancing the quality of teaching, and widening access to flexible, and quality higher educational opportunity to millions of working and non working adults in least developed countries. It will constitute an important and novel source of new knowledge and provide a better understanding of the area to both researchers and managers.

References
Ahmad, El-Sobky (2004). “Emerging e-learning in Developing Countries: Challenges and Opportunities.” Information for Development (i4d), 2004


Claudia Sarrocco (2002). Improving the IP connectivity in the least developed countries: breaking the Vicious circle. Claudia Sarrocco Journal: info ISSN: 1463-6697


Goddard, A. (1998). Facing up to market forces; Times Higher Education Supplement


