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An Early-Stage ICT Maturity Model derived from Ethiopian education institutions

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ABSTRACT

Developing an initial ICT infrastructure in education institutions is disproportionately expensive in developing countries and sustainable interventions are difficult to achieve. There has been a lack of concrete guidance regarding the stages of development needed to make efficient use of resources and maximise the chances of sustainable investments. To address these needs, an ICT Maturity Model is presented that has been derived from documentary sources and an analysis of selected schools, colleges and universities in Ethiopia. The surveyed institutions include five primary schools, six teacher education colleges, five public universities and a higher education preparatory school. The Model defines the ICT infrastructure resource levels required to achieve primary organisational objectives expressed in the form of student learning outcomes. The Model consists of eight levels, with the focus being on the lowest levels defining the infrastructure required to enable initial computer training. The levels in the Maturity Model show management, teaching and technical staff, as well as donors how to make most efficient use of ICT resources by maximising opportunities for student learning. Although developed and tested in the Ethiopian context, it is hoped that the Model can be replicated across a range of developing countries.

Keywords: *Information and Communication Technology (ICT); Maturity Model; Stage Model; Educational Institution; College; University; ICT for Development, Educational Development; Ethiopia.*

INTRODUCTION

There has been considerable interest in the use of information and communication technologies (ICTs) in the education sector worldwide. Further, there has been growing interest in the use of ICTs in educational settings in developing countries (Tolani-Brown, McCormac & Zimmermann, 2009). Non-governmental initiatives have included attempts to integrate ICT into rural and low-income urban schooling (Brewer, et al., 2005) and the much publicized One Laptop Per Child initiative (Kraemer, Dedrick, & Sharma, 2009). Further, in recent years, several countries have attempted donor-led (Unwin, 2004) or government-led initiatives to expand access to ICTs in schools. These initiatives have often been associated with a broader educational quality improvement agenda. Interventions have included investment in new computer classrooms, and schemes to provide teachers with laptops (Gülbahar, 2008).
The use of computers in education has realized many benefits. Research shows that ICTs can contribute to enhancing education in a development context in a number of ways:

- Increasing the number of qualified teachers by accelerating teacher training (Unwin, 2004),
- Improving achievement levels by helping to counter adverse factors such high student:teacher ratios, shortage of basic teaching materials and poor physical infrastructure,
- Reducing drop-out rates by making learning more interesting and stimulating (e.g. Light, 2009),
- Overcoming geographical obstacles through distance learning (e.g. Rye, 2009) and

- Changing pedagogical practices and providing access to educational content and up to date resources (e.g. Webb and Cox, 2004).

Other student benefits may include greater opportunities for post-school employment, and greater motivation for ICT-related careers.

Despite these benefits, shortcomings have also been found. For example, Wims and Lawler (2007) report teachers having to share computers with other school staff. They show sometimes comparatively little educational use of the ICT resources is made in subjects other than computer skills training. This shortcoming supports other research advocating attention to technical, subject-specific (content) and pedagogical knowledge (Koehler & Mishra, 2009). The Wims and Lawler (ibid) research also demonstrated the need for staff training and staff computer access to encourage the educational mainstreaming of ICT which has been identified in research conducted elsewhere (Shephard, 2004).

In an investigation of the obstacles to greater use of ICTs in African schools, Kessy, Kaembe, & Gachoka (2006) report several reasons, which fall into two main camps. First, is the lack of tangible resources such as technology, money and electricity. These factors point to the need for effective planning in order to make best use of the few resources that can be brought to bear on education. Yet the second problem relates to human resource shortcomings around awareness, competencies and governance, which make such effective planning all the more difficult to achieve.

Among other issues, it can be seen that education institution managers, teachers and senior academics in developing countries lack ICT planning and infrastructure implementation knowledge. Guidance on this could help make better use of scarce resources, develop in-house skills and cope with rapid technological change by focusing on key organizational objectives. One form in which such guidance could come is an ICT Maturity Model.

This article considers the early stages of development of ICT infrastructure in education institutions in Ethiopia. A novel ICT Maturity Model is presented which has been derived from analyses of schools, colleges and universities. As will be shown in the following pages, the levels of the Maturity Model link ICT resources to student learning outcomes. Further, the levels have been selected to maximize the efficient use of available computing resources for the benefit of student learning opportunities.

The primary contribution of the research presented in the following pages, is the way the new Maturity Model links the stages of an organization's ICT development to the potential student learning outcomes made possible at each level. The objective of creating new student learning outcome opportunities becomes the major driver for targeted investment to move from one developmental stage to the next. The purposes of the Maturity Model are to:-

- Provide a planning framework for stakeholders in educational institutions,
- Enable advocacy of a systematic series of developmental stages,
- Foster efficient and sustainable use of existing installed infrastructure resources, and to
- Guide investment in ICT resources so they are targeted to enhance student learning outcomes.

Maturity Models

It is intuitively attractive to define the ICT adoption of organisations as a series of clearly articulated developmental stages. This was first posed as a hypothesis by Richard Nolan at Harvard University (Nolan, 1973). Despite being developed in the 1970s the model remains influential (Wikipedia, 2010). Nolan identified four stages:

- Stage I: Initiation (computer acquisition), initial introduction of computers into the organisation
- Stage II: Contagion (intense system development), management implements policies and plans to improve utilisation of computer resources
- Stage III: Control (proliferation of controls) usually follows a crisis of out-of-control computing expenditure and poorly planned and executed automation projects, and
- Stage IV: Integration (user/service orientation) reassessing the role of computing resources in the achievement of organisational goals.

In a subsequent paper Nolan (1979) adds two further stages of maturity:

- Stage V: Data Administration management is focused on information flows, storage and management, and
- Stage VI: Maturity computing resources precisely mirror the information flows within the organisation.

A problem with the Nolan model is that it uses computing budget expenditure (rather broadly defined) as a surrogate measure for a wide range of ICT developmental infrastructure properties. The validity of using budget to represent organisational environment, management strategies and institutional skills-base has been questioned (King and Kramer, 1984).

Budget expenditure is also an important driver in Nolan's model for the transition from Stage II to Stage III, the suggestion being that it is mushrooming ICT budgets that precipitate imposition of controls in the ICT environment. In recent years, the benefits of ICT policies and management plans have come to be seen as good practice in themselves and not necessarily motivated by any need to control ICT budgets. The Nolan plan has been important for identifying that the motivation for growth in computing use comes from factors both internal and external to organisations (King and Kramer, 1984). Also, that there is a dialectical relationship between freedom and constraint in the control of computing that leads to certain states of equilibrium (King and Kramer, 1984).

The primary contribution of the research presented in the following pages, is the development of a new Maturity Model that links the stages of an organisation's ICT development to the potential student learning outcomes made possible at each level. This new Maturity Model decouples budgets from being the major driving force propelling organisations through ICT development stages. Rather, the objective of creating new student learning outcome opportunities becomes the major driver for targeted investment to move from one developmental stage to another. The aim is to link ICT infrastructure investment to primary organisational objectives, expressed in the form of student learning outcomes.

The rest of the paper is structured as follows. The next section of this paper introduces the levels of the proposed Maturity Model. The Maturity Model provides the structure for the main findings of the paper. The data collection methods are then introduced; this includes results of a survey of schools in the city of Debre Birhan, Colleges of Teacher Education predominantly located in the Amhara Region of northern Ethiopia and selected public universities. The derivation of the new ICT Maturity Model from findings in the surveyed institutions is then presented. This includes surveys of in-service and pre-service trainee teacher ICT skills. Finally there is a discussion of the findings and evaluation of the Maturity Model. The paper finishes with concluding remarks and an indication of areas of future work.

A NEW ICT MATURITY MODEL FOR EDUCATION INSTITUTIONS

The new Maturity Model was informed by several documentary sources and derived from analysis of surveyed education institutions. The International Computer Driving License, ECDL/ICDL (2009) provides a detailed breakdown of desirable computer user skills. The syllabus has seven units which are: concepts of IT, computer use and managing files, word processing, spreadsheets, databases, presentations and information and communication (Internet use). The introductory unit needs no computers at all. Where there is a shortage of resources the introductory unit can be taught in a classroom environment, rather than using a computer laboratory. Computer access would, of course, be desirable to enliven the teaching and learning experience. The second unit requires computers with only an operating system installed (to learn about file management tasks), while four units use standard office application software. The final unit has need of an Internet connection with sufficient bandwidth to support a (potentially large) student group. The analysis of this well-established syllabus for computer use skills provides a basic foundation for the idea of linking levels of infrastructure maturity to learning outcomes.

In addition to computer users, catered for by the International Computer Driving License, there is also a need to consider demand for skilled IT professionals. University computing curricula are required in order to train a future generation of technology leaders. Detailed degree curricula guidelines have been produced by the Joint IEEE/ACM Computing Curriculum Task Force. Important work to establish the commonalities and distinctive features of five computing subject areas has been helpful: computer science, computer engineering, information systems, information technology and software engineering (IEEE/ACM, 2005).

The Skills Framework for the Information Age (SFIA) provides a detailed taxonomy of 86 specialist ICT practitioner skill areas and 290 tasks (SFIA, 2009). The SFIA was not produced with developing countries in mind. However, merging the skill areas within categories can provide a useful model of desirable student learning outcomes and organisational support activities for a developing country context.

These documentary sources can thus be used to gain improved understanding of skills outcomes from the perspective of computer users, education curricula guidelines and ICT practitioners. They also offer the basic connection between those outcomes and both infrastructural resources and organisational stage. But this is just a background of ideas and structures, and with little specific developing country relevance. To take the idea of the new model further, fieldwork was required.

A summary of the Maturity Model is shown in Table 1. Derivation of Levels 1 to 5 in the model, which focus on the early stages of ICT infrastructure development, will be described in the following pages. Derivation of the final three levels, a detailed discussion of which is beyond the scope of this paper, were drawn from scholarly visits to two well-established universities in India (IIT-B and IIIT-B) and a series of professional body accreditation visits to UK universities.

Table 1. *Education Institution ICT Maturity Model Summary*

	Institutional Maturity Levels	Resource Milestones	Potential Learning Outcomes
Level 1	Aspirant	Built environment	Theory only
Level 2	Generic Hardware and Software	Electricity Computers installed	Computer operation Mouse and keyboard manipulation
		Application	Courseware development

	Institutional Maturity Levels	Resource Milestones	Potential Learning Outcomes
		software	Course delivery Operating systems skills Application software skills
Level 3	Teaching and Learning Administration (Early Adopters)	Technician support	Backup and restore Archiving Data security In-service staff training
Level 4	Generic Internet (Early Adopters)	High-speed Internet	Web searching Web-based email accounts
Level 5	Critical Pedagogy (Early Adopters)	Higher-learning support	Broad, high-level ICT education knowledge (up to postgraduate)
Level 6	Teaching and Learning Administration (Mainstreaming)	Mainstreaming support	Backup and restore Archiving Data security
Level 7	Generic Internet (Mainstreaming)		Web searching Web-based email accounts
Level 8	Critical Pedagogy (Mainstreaming)	Higher-learning mainstreaming support	Deep subject domain knowledge (up to postgraduate)

The rows in Table 1 represent maturity stages within an education institution. Maturity levels build upon each other from Level 1 to Level 8. So, each row is dependent on achieving the level of maturity described in the rows above. The resource milestone column represents ICT infrastructure required to achieve institutional objectives expressed in the form of potential learning outcomes at each maturity level. A review of the eight maturity levels in the model is presented below.

Level 1 Aspirant

Institutions that have yet to obtain installed computers map to the Aspirant Level of the Maturity Model. Such institutions are restricted to teaching ICT from a theoretical perspective only. A detailed breakdown of potential learning outcomes in this level is presented in the ECDL/ICDL Unit 1 syllabus (ECDL/ICDL, 2009).

Level 2 Generic Hardware and Software

Access to electricity, a power distribution infrastructure and the installation of computers with standard office application software enables transition from Level 1 to Level 2 in the model. This Maturity Level corresponds to the technology dimension of the ITPOSMO model (Heeks, 2002). This level of infrastructure enables teaching of file management, word processing, spreadsheet and presentation application skills. At this level of maturity these are generic user skills, such as the basic skills described in Units 2-6 of the ECDL/ICDL syllabus (ECDL/ICDL, 2009).

Level 3 Teaching and Learning Administration (Early Adopters)

The key mechanism defining progression from Level 2 to Level 3 is the establishment of a technical support service within the institution. The need for technical support becomes more pressing as the number of computers increases and the institutional dependency on computing resources grows. Supporting teaching staff as they acquire ICT skills is important as low skill levels are associated with high levels of anxiety and negative attitudes towards technology (Intaganok et al., 2008) The helpdesk technician support skills map to basic service provision

skills in SFIA (2009) and to the Information Technology subject emphasis in the joint IEEE/ACM Computing Curriculum (IEEE/ACM, 2005).

There are opportunities at this level of the Maturity Model in a teacher training college for students that are pre-service trainee teachers to acquire ICT skills that directly relate to their role as teachers. This is particularly important prior to any practical training component providing classroom experience (Clarke, 2007). In addition all types of education institutions at Level 3 have the infrastructure and in-house skills to undertake in-service staff development training.

Level 4 Generic Internet (Early Adopters)
Provision of Internet access with sufficient bandwidth to enable institutional use enables access to a wide range of online learning resources. With this resource, for example, pre-service trainee teachers have the opportunity to learn generic browser use and web navigation skills. The use of English keywords, for those for whom English is not their first language, is a particular challenge.

These basic skills can be used to facilitate personal communication, for example with friends and family abroad. The skills are also used to support personal professional development, for example through applications for scholarships.

Level 5 Critical Pedagogy (Early Adopters)
At this maturity level experienced learners are able to participate in the global online community in their discipline. Experienced learners communicate with peers of national and international standing. They have knowledge of authoritative online sources of information. They are able to critically assess the quality of information sources and select only high-quality sources that suit the needs of their own learning and support production of quality learning materials.

Levels 6 to 8 Mainstreaming
The mechanism for defining migration from Level 5 to Level 6 is the establishment of a staff development support service to encourage adoption of office application software by teaching staff, for example see Shephard (2004). Distinctive disciplinary dissemination issues become more pronounced during mainstreaming (Kemp & Jones, 2007). A detailed discussion of these levels is beyond the scope of this paper.

DATA COLLECTION

Data collection instruments were used to examine 6 schools, 6 colleges of teacher education, 5 public universities and a higher education preparatory school during the conduct of this research. The survey of ICT provision in six schools was conducted in Debre Birhan between May and July 2007. The six Colleges of Teacher Education (CTEs), surveyed during December 2006 and January 2007, are in the Amhara Region (Debre Birhan, Debre Marcos, Dessie and Gondar) with one each in Southern Nations, Nationalities and Peoples Region (Dilla) and Tigray (Abbiye Addi). The survey of ICT status in five public universities (Addis Ababa, Hawassa, Dilla, Debre Marcos and Wolaita Sodo) was conducted for the Higher Education Strategy Centre of the Ministry of Education, between June and October 2009.The approximate location of these institutions is shown in Figure 1. These cross-sector surveys provide insights into the evolution and maturity of IT Infrastructure at institutions with different resource levels. This can be seen as a multiple case study approach (Yin, 2008).

Figure 1. *Location Map Showing Approximate Institution Locations in Ethiopia*

The ICT Status surveys involved site visits, interviews with management teaching staff and students. Simple questionnaires were used as survey instruments to capture key features of institutions. The questionnaires were filled in by researchers and senior officers during site visits. In addition, interviews were conducted with key staff (Directors, Head of IT, etc) and triangulated with student focus groups.

Extracts of more detailed surveys of staff and student computer use and IT skills are presented. These were conducted in the college of teacher education and higher education sectors where more evidence of pedagogical IT use was observed. The survey questions were based on those advocated by UNESCO (2006) for international school surveys. The criteria were selected to enable comparison with other countries elsewhere in sub-Saharan Africa. This form of survey (like all research approaches) has strengths and weaknesses. There are a number of reasons why respondents might under- or over-represent their access to ICT resources or levels of skill. However, the respondents were either practicing teachers or trainee teachers and felt to have the maturity to answer questions with honesty and integrity. ICT skill assessment using practical testing would be desirable but requires substantial resources to administer.

MATURITY MODEL DEVELOPMENT

Background: Public Education in Ethiopia

Before describing the survey data that helped form the Maturity Model, it is necessary to understand Ethiopia's public education system.

The public education system in Ethiopia has a stated objective to use the development, deployment and exploitation of ICTs to help develop Ethiopia into a socially progressive and prosperous nation with a globally competitive, modern, dynamic and robust economy (FDRE,

2002). Simultaneously, the education sector has been identified by the Government as a priority area. Thus Ethiopia presents a good example of a developing country in which the use of ICTs in education has received central support (Hare, 2007).

Management of education institutions in Ethiopia is partially decentralised, as shown in Figure 2. The Figure shows that Regional Education Bureaux have responsibility for financing and supervising schools and the College of Teacher Education sector. Both the Regional Education Bureaux and public universities are responsible to the Ministry of Education.

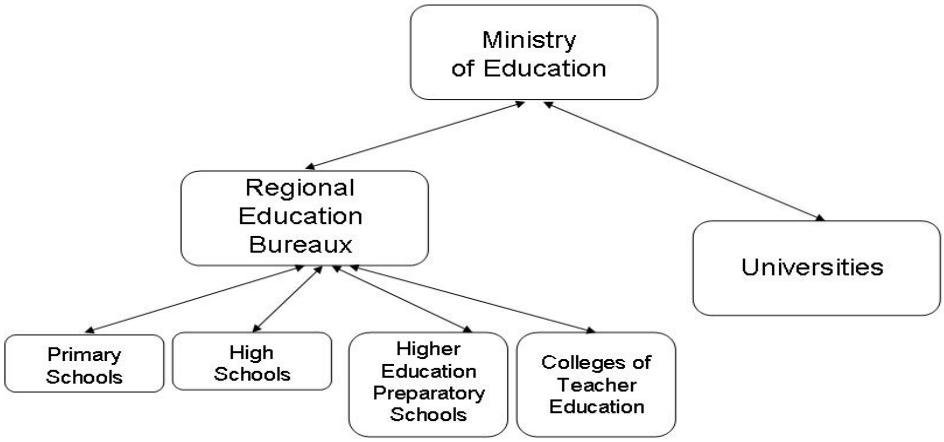

Figure 2. *Management of Education Institutions in Ethiopia*

School student progression in Ethiopia is based on a system of national examinations at Grades 8, 10 and 12. Children have entitlement to free education up to Grade 8, after which it is based on achievement. Figure 3 shows how students progress from institution to institution and might eventually gain employment as teachers, or elsewhere.

Primary school teachers are required to obtain a two-year Diploma, while those teaching in higher schools require a Bachelors degree. The country also has ambitious university expansion plans. The number of universities was more than doubled in 2007, from nine to 22. A further ten universities are planned over the next four years, though there have been warnings about the difficulty of maintaining quality during a period of such rapid expansion (Saint, 2004).

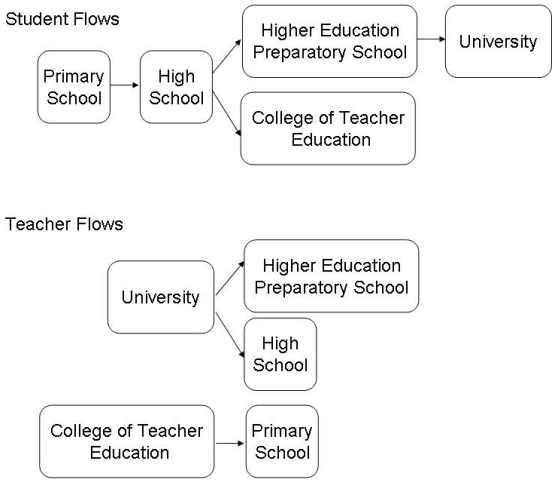

Figure 3. *Student and Teacher Flows through Education Institutions*

Primary and Secondary Schools

The city of Debre Birhan is administrative centre of the North Shoa Zone, within the Amhara Region of highland Ethiopia 130km north east of the capital Addis Ababa (see Figure 1). Rural "first cycle," Grades 1 to 4, primary schools in the hinterland of Debre Birhan have buildings that use basic construction techniques and locally available materials (such as timber and mud). Larger first and second cycle, Grades 1 to 8, rural schools are typically constructed using simple concrete blocks and tin sheet roofing. These schools do not have access to piped water or electricity in common with other parts of rural Africa (UNESCO, 2006).

A survey of school directors at urban primary and secondary schools in Debre Birhan itself showed that none had an ICT infrastructure in place that can be used to support teaching and learning. These urban schools have both electricity and telephone access, so in principle the pre-requisite infrastructure is in place. However, resource limitations mean that none of the surveyed schools actually have computing resources available to support teaching. They have not yet been able to procure sufficient computers to conduct in-service training to further develop ICT skills of teaching staff. An overview of results, based on questionnaire feedback from staff, in the five urban schools serving 3,802 pupils, is shown in Table 2.

Table 2. *Overview of Primary and Secondary Schools in Debre Birhan*

School Name and Status	Grades	Teachers	ICT Certified Teachers	Pupils	Pupil to ICT Teacher Ratio	Educational Use of Computers	
						Computers	Classrooms
Blanc Mesnie Academy (Private)	1-6	20	3	142	47:1	0	0
Soressa (Private)	1-6	30	15	479	32:1	0	0
Model 1 (Public)	1-6	16	0	492	N/A	0	0
Tebassie Primary (Public)	1-8	39	5	1424	285:1	0	0
Baso General Secondary (Public)	9-10	19	0	1265	N/A	0	0
Totals and Average		124	23	3802	165:1	0	0

The schools shown in Table 2 have yet to acquire computers to support educational objectives or outcomes. An introductory level, Level 1, in the Maturity Model can be created to accommodate these institutions, as shown in Table 1. The schools in this level are able to teach ICT in theory only and are unable to teach practical computer use skills, since they are without mouse and keyboard hardware.

Tertiary Education Institutions

School leavers progressing from Grade 10 have two options, depending upon their national exam results, as shown in Figure 3. Students with the best exam results can enter the Higher Education Preparatory School system, and study Grades 11 and 12. Good students who do not score a high-enough grade for Grade 11, may have the chance to join the Teacher Education College sector. All these institutions typically do have some level of ICT infrastructure used for teaching and learning in Ethiopia. First, let us consider the College of Teacher Education sector.

ICT Infrastructure in the College of Teacher Education Sector

There are about 22 Colleges of Teacher Education (CTEs) in Ethiopia, responsible for awarding Diplomas to primary education teachers. An overview of the survey results from six institutions is shown in Table 3 (see Figure 1 for approximate locations). The shortage of resources, relatively few computers and qualified staff available for ICT teaching, is evident from the Table.

Table 3. *College of Teacher Education ICT Survey Overview*

College	Region	Student Population	ICT Teachers	ICT Technicians	Internet Bandwidth	Student to Computer Ratio
Abbiye Addi	Tigray	970	2	0	56kbps	42:1
Debre Birhan	Amhara	1,115	2	1	56kbps	65:1
Debre Marcos	Amhara	1,500	1	0	2 x 56kbps	30:1
Dessie	Amhara	-*	2	0	128kbps	-
Dilla**	SNNP	1,300	4	2	128kbps	16:1
Gondar	Amhara	650	2	2	2 x 56kbps	13:1

* Student population information not available
** Dilla was upgraded to university status in 2007

These institutions show a diversity of ICT infrastructures. In Table 4 the colleges are categorised along two axes: Internet connectivity and helpdesk technician provision. The diversity in this Table reflects a lack of clarity regarding the use of technology to support the core purpose of teaching and learning.

Table 4. *ICT Categorization of College of Teacher Education Sector*

		Helpdesk Technician Support	
		NO	YES
Internet access	Dial-up	Abbiye Addi CTE	Debre Birhan CTE
	Broadband (128kbps or better)	Debre Marcos CTE Dessie CTE	Dilla CTE Gondar CTE

Abbiye Addi College, in Tigray Region, has neither high-speed Internet nor helpdesk technician support. Maturity Model, Level 2, can be created to accommodate such institutions that have electricity, where computers are installed and used for teaching purposes, as shown in Table 1. Two distinctive features of institutions in Level 2 are the absence of helpdesk technician support or high-speed Internet connectivity. This is a maturity level required for institutions using computers for any education purpose (e.g. for education, health or agriculture). Basic computer use and manipulative skills must be acquired by students before any unsupervised usage of a computer is advisable.

Debre Birhan CTE, has the resources to provide a helpdesk technician support service and is in Level 3 of the Maturity Model, as shown in Table 1. The services that are provided at this level of maturity include equipment repair and fault-finding, ensuring data integrity and security procedures such as virus protection. These helpdesk service skill areas are described in SFIA (2009). The model also encourages the use of technicians to provide user support and in-service staff development training.

Investigation of computer use frequency and prevalence of ICT skills is now possible, given the presence of computer classrooms and use of computers in teaching. A survey of 179 3rd year diploma students was conducted to obtain a snapshot of usage patterns at the Debre Birhan

College of Teacher Education. The survey results shown in Table 5, demonstrate that trainee teachers do not use the computational power of computers to enrich their own learning. A single numerical value, the overall usage score, has been calculated to simplify comparison of the results. Teachers are not conducting computer-based simulations or experiments (both attracting an overall usage score of 5). Further, they rarely use e-books or the Internet for information gathering either (attracting an overall usage score of 27).

Table 5. *Frequency of ICT Usage by 3rd year Diploma Students*

	Everyday or Almost Everyday	**Once or Twice a Week**	**Once or Twice a Month**	**Never or Almost Never**	**Overall Usage Score[1]**
How often do you watch movies, videos or television to obtain information?	34%	6%	1%	60%	250
How often do you use the computer to practice skills and procedures?	12%	79%	8%	2%	205
How often do you use computer technology at school/college?	0%	100%	0%	0%	150
How often do you compare material presented in different media?	0%	6%	56%	38%	28
How often do you use computer technology to find information (Internet, CD-ROM)?	3%	0%	6%	91%	27
How often do you use computer technology outside school/college?	1%	1%	12%	80%	16
How often do you use the computer to do scientific procedures or experiments?	0%	0%	0%	100%	5
How often do you use the computer to study natural phenomena through simulations?	0%	0%	0%	100%	5

[1] The overall usage score is calculated using the formula:

$$score = \sum (Column2 * 7) + (Column3 * 1.5) + (Column4 * 0.3) + (Column5 * 0.05)$$

The ICT skills self-assessment of the same 3rd year diploma students are shown in Table 6. These results show students exhibiting basic computer use skills. For example, the use of mouse operations to navigate a document attracts an overall task frequency score of 702; and opening a file attracts an overall task frequency score of 552. However, students are ill-equipped to prepare a multimedia presentation (overall task frequency score of 209), which might enrich their own learning and enliven classes for their pupils. It can also be seen from Table 6 that, while basic computer use skills are acquired, little use is made of computers for broader educational objectives or deeper student learning outcomes. These results confirm the findings of other studies conducted in sub-Saharan Africa (e.g. Wims & Lawler, 2007). The levels in the Maturity Model have been designed to distinguish computer use learning (Level 2) from technology-mediated learning of subject specific critical thinking skills (Level 5) informed, in part, by these survey results.

Table 6. *Student Self-Assessment of ICT Skills*

	Performed the task many times	Have performed the task alone	Might need a little help to perform the task	Need help to perform this task	Overall Task Frequency Score [1]
Scroll a document up and down the screen?	170	4	5	0	702
Save a computer document or file?	120	45	3	11	632
Use a database to produce a list of addresses?	100	40	5	34	564
Open a file?	120	5	3	51	552
Start and shutdown the computer?	21	145	13	0	545
Start a game?	55	5	0	119	354
Play computer games?	50	0	0	129	329
Create a multimedia presentation (with sound, pictures and video)?	5	5	5	164	209

[1] The overall task frequency score is calculated using the formula:

$$score = \sum (Column2 * 4) + (Column3 * 3) + (Column4 * 2) + (Column5 * 1)$$

A prescriptive element of the Maturity Model in Level 3 as shown in Table 1, is introduced to encourage the application of newly acquired computer use skills to educational tasks and processes (in the case of a College of Teacher Education), rather than teaching computer use as an end in itself. Preparation of presentation materials, learning support materials, using spreadsheets to manage assessment results are ways that teachers can enliven the learning process and make efficient use of their time for teaching administration tasks.

The preparation of multimedia learning resources and use of computers for simulations and experiments using CD-ROM and DVD-based resources becomes a reality for Level 3 institutions, even though they do not at that stage have high-speed Internet access. In this way institutions can make better and more efficient use of resources they already have, before making additional purchases of further expensive infrastructure.

The Maturity Levels observed at selected schools and colleges are summarised in Figure 4. Tebassie Primary and Baso Secondary, shown in Table 2, have no computer classrooms and so are in Level 1. Abiye Addie CTE and Debre Birhan CTE are in levels 2 and 3 respectively, as discussed above.

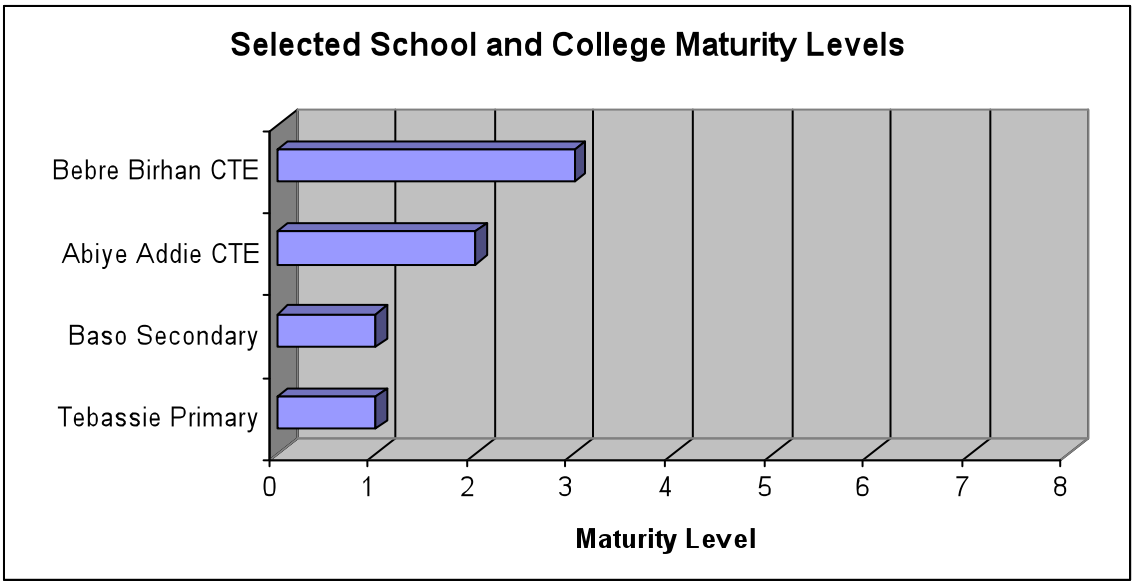

Figure 4. *Maturity Levels at Selected Schools and Colleges*

Referring to Table 3 institutions, such as Gondar CTE and Dilla, can be seen to have both a helpdesk technician service and high-speed Internet access. These institutions are in Level 4 of the Maturity Model, as shown in Table 1. The Internet access enables classroom teaching of Internet browsing, use of online email services and the use of search engines. These user skills are described in Unit 7 of the ECDL/ICDL syllabus (ECDL/ICDL, 2009). They should be applied to enhancing the learning experience of students, by accessing external information sources or subject experts.

Higher Education Sector

The higher education sector ICT status survey included five public universities and the Hailemariam Mamo Higher Education Preparatory School, as summarised in Table 8.

Two of the universities surveyed were under construction on green-field sites, Debre Marcos and Wolaita Sodo. These universities have technician support but no high-speed Internet. This places these institutions at Level 3 in the Maturity Model. However, the ICT teaching was predominantly generic computer user training (Level 2) in the form of common courses given by specialist ICT teachers to students of other subjects. The higher education sector maturity levels observed are summarised in Figure 5.

Dilla had a new campus under construction on a green-field site but also a well-established older campus and so benefited from some previously-installed infrastructure. The old campus did have a high-speed Internet connection (Level 4) although there was a lack of connectivity on the new campus (which is at Level 3).

Table 8. *Summary of Public University Sector ICT Status*

Institution	Foundation Date	Student Population	Computers for Classroom Use	Student to Computer Ratio
Addis Ababa University	~1955	50,492	1,608	31:1
Dilla*	2007	7,153	134	53:1
Debre Marcos University	2007	6,462	58	111:1
Hailemariam Mamo HEPS	-	1,603	30	53:1
Hawassa University**	April 2000	15,420	242	64:1
Wolaita Sodo University	March 2007	3,653	52	69:1

* Previously Dilla CTE
** Formerly known as Debub University

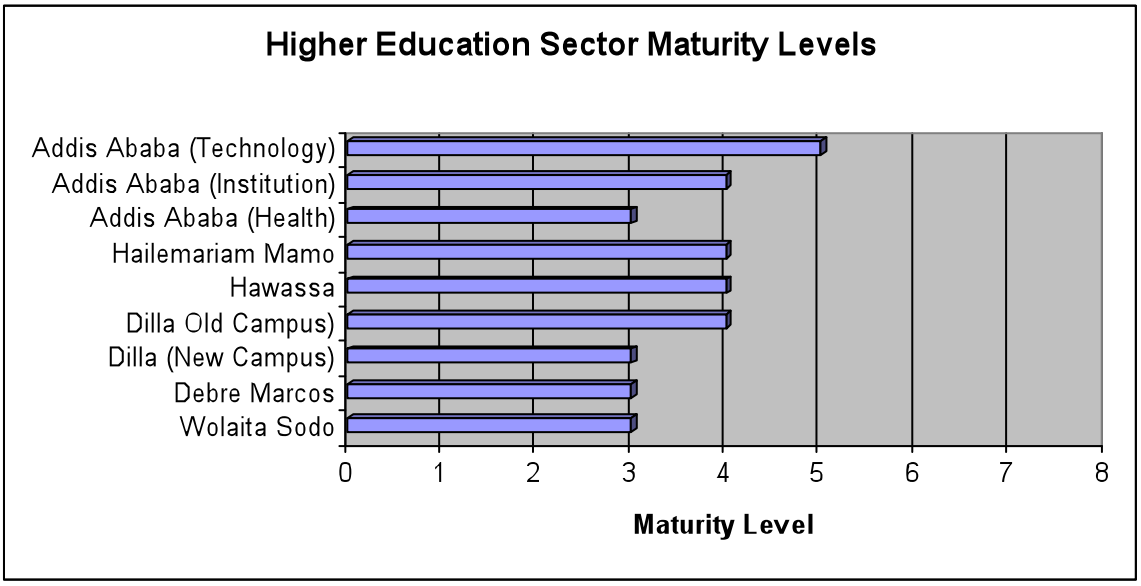

Figure 5. *Higher Education Sector Maturity Levels*

The Hailemariam Mamo Higher Education Preparatory School also has high speed Internet access (Level 4) but there is no technical support service or helpdesk technician (Level 3). There were reports of severe reliability problems with the Internet access, leading to outages lasting weeks and even months. Provision of a technical support service could alleviate these reliability problems.

The ICT use survey results for the Hailemariam Mamo higher education preparatory school teachers are shown in Table 8. It can be seen that large numbers of serving teachers are obtaining information from movies, videos or televisions (overall usage score 454). Also, a few

ICT early adopters are using computers to conduct simulations (overall usage score 20) and procedures or experiments (overall usage score 49).
Comparisons can be made of results for preparatory school teachers shown in Table 8 with the pre-service trainee teacher survey results shown in Table 5. It can be seen that more serving teachers have access to movies, videos or televisions.

Table 9. *Frequency of ICT Usage by Preparatory School Teachers*

	Everyday or Almost Everyday	Once or Twice a Week	Once or Twice a Month	Never or Almost Never	Overall Usage Score [1]
How often do you watch movies, videos or television to obtain information?	59%	27%	0%	0%	454
How often do you compare material presented in different media?	18%	23%	27%	9%	169
How often do you use the computer to practice skills and procedures?	18%	14%	41%	14%	160
How often do you use computer technology at school?	14%	27%	41%	5%	151
How often do you use computer technology to find information (Internet, CD-ROM)?	9%	9%	27%	41%	87
How often do you use computer technology outside school?	5%	14%	18%	50%	64
How often do you use the computer to do scientific procedures or experiments?	5%	5%	9%	68%	49
How often do you use the computer to study natural phenomena through simulations?	0%	9%	9%	68%	20

[1] The overall usage score is calculated using the formula:

$$score = \sum (Column2 * 7) + (Column3 * 1.5) + (Column4 * 0.3) + (Column5 * 0.05)$$

Addis Ababa and Hawassa Universities were founded earlier than the other surveyed universities. Thus, both have a longer history during which to have developed their IT infrastructure. Also, Addis Ababa University has a large student population, of over 50,000 students, compared with others in the country, which justifies analysis of the institution at Faculty level. Addis Ababa has an ICT Development Office which is rather more focused on infrastructure than pedagogy. Some examples of using ICT to support teaching and learning were observed, e.g. in the Faculty of Technology and the Faculty of Informatics. There was evidence of institutional support for use of the ICT for critical pedagogy, including learning support providing subject specific e-Library application software support. Masters students undertake dissertation project work that, at some level, engages with the international body of published literature in their chosen field. This enables creation of a new level in the Maturity Model, Level 5, as shown in Table 1. Students in the Addis Ababa University Medical Faculty, in contrast, are relatively underserved in terms of computer access, as shown in Figure 5.

Students outside the Computer Science Department at Hawassa had very limited computer access. Open access computers, such as those in libraries, were almost exclusively for use by postgraduate students. Although new classrooms were under construction, but these would primarily be used by ICT teachers to teach computer use skills to students of other subjects.

The universities surveyed in Ethiopia have not established support processes or a staff development team dedicated to assisting staff in ICT for learning adoption. This lack of support processes makes it difficult for staff outside early adopter faculties to learn about the benefits of supplementing face-to-face teaching with electronic learning resources. The lack of any organised learning technology mainstreaming effort goes some way to explaining the wide variations between ICT provisions in faculties at Addis Ababa University. The provision of mainstreaming support is characteristic of Level 6 of the Maturity Model, as summarised in Table 1.

MATURITY MODEL EVALUATION AND DISCUSSION

The central point above is that the Maturity Model levels are distinct and measurable phases in accordance with requirements defined by Kuznets (1965 quoted in Nolan, 1973). The stages of the ICT Maturity Model are *evolutionary* and do not preclude an organisation from regressing through the levels, perhaps because of deteriorating resources (King, 1984).

The Maturity Model was developed, in the light of survey data, to highlight the importance of ICT support for student learning (the main mission of all learning establishments) and the benefits of obtaining technician support, before Internet access is emphasised. The Maturity Model links ICT infrastructure to the primary organisational objectives of an education institution expressed in the form of student learning outcomes. The model is intended to be prescriptive, advocating best practice in ICT infrastructure development in an education institution. Within institutions at Level 2 of the Model there is a tendency for teaching to focus on computer use as an end in itself. The Maturity Model levels have been designed to advocate application of computer use skills to support subject specific learning. For example, trainee teachers should be encouraged to apply their computer use skills to the preparation of engaging teaching materials, assessments and so on.

Table 10. *Maturity Evolution Choices*

		Helpdesk Technician Support	
		NO	YES
Internet access	Dial-up	Level 2 ⇩	⇨ ?
	Broadband (128kbps or better)	?	Level 4

A key question facing managers of institutions at Level 2 is how to further develop their ICT maturity. This dilemma is illustrated in Table 10. In what sequence should a college attempt to set up a helpdesk technician resource and purchase a higher-speed Internet connection? Resource

constraints rarely allow a college to do both in a given financial year. So which one should come first?

Two of the Colleges, Debre Marcos and Dessie, and the Hailemariam Mamo higher education preparatory school have broadband Internet access without any helpdesk technician support. These colleges are characterised by large numbers of computers that are broken and not in use or are infected with numerous viruses. Teaching staff typically do not have the skills or resources to repair broken machines.

Drawing on these experiences, it is proposed that the Maturity Model advocates helpdesk technician provision before purchase of broadband Internet connection. This is because technical support can improve the chances of sustainable use of the servers and network infrastructure associated with the higher-speed Internet service.

More generally, prioritisation – driven by the model – of institutional objectives in the form of student learning outcomes can be used to de-emphasise support for management information systems or organisational promotion through Web sites. But the model can be used to argue that automation of manual processes can only be undertaken when a sustainable support infrastructure is in place. Anecdotal evidence of major data loss incidents, for example resulting from virus infections, suggests that reliance on computers for storage of mission-critical data without a support infrastructure would be premature.

Applying the Maturity Model to larger and more complex institutions, such as major high schools or universities, is somewhat more complex. It is inevitably something of an over-simplification to condense diverse examples of practice into a single Maturity level; instead applying the model at the Faculty or even departmental level is advocated. No surveyed institutions demonstrated any institution-wide effort to support the use of ICT for teaching and learning; and so are restricted these institutions to Level 5, at best. Some faculties are supporting staff members who use technology to support higher learning (Level 5) and yet some departments are still only teaching students generic computer use skills, not linked to any subject-specific pedagogy (Level 2).

CONCLUSION

A Maturity Model has been derived from documentary sources and the observation of ICT status in Ethiopian educational institutions ranging from primary schools, which are yet to have the resource infrastructure to undertake any ICT-related teaching and learning, through to universities with tens of thousands of students. The model has eight levels describing the most basic physical infrastructure with which only theory can be taught (Level 1) through to the infrastructure required to mainstream e-research and the teaching of advanced (up to postgraduate) critical thinking and reasoning skills (Level 8). The model links the stages of development of an institution's ICT infrastructure to the organisation's primary objectives expressed in terms of the student learning outcome opportunities created.

Derivation of the model in Ethiopia revealed that:

- There is a tendency to teach computer use skills as an end in themselves, rather than applying them to any subject-specific pedagogy,
- Insufficient use is made of computing resources for in-service staff development,
- The benefits of helpdesk technician support are not fully appreciated, and
- Learning outcomes were not being significantly enhanced by Internet access.

To address these structural weaknesses the model supports advocacy to prioritise ICT investment towards student learning outcomes. Level 2 of the model highlights the development

of computer use skills, but also the application of those skills to the student's field of study. For example, trainee teachers should have the opportunity to use computers to prepare learning resource materials. Infrastructure available at Level 2 enables teaching staff to use subject-specific multimedia resources to enrich and enliven learning experiences. Level 3 of the Maturity Model emphasises the benefits of helpdesk technician support to resolve technical problems and provide user-support to teaching staff. Employment of technicians helps retain and develop in-house skills, improving sustainability of infrastructure investment. Technician support enables greater institutional reliance on ICT for mission-critical purposes. Institutions at Level 3 are also encouraged to maximise the use of existing computer classroom resources for the purpose of in-service staff training. These measures can usefully be instituted prior to obtaining scarce and expensive Internet access. Level 4 of the model, in turn, links access to high-speed Internet to browsing, searching and communication. Here skills described in Unit 7 of the ECDL/ICDL (2009) syllabus are developed to support communication with external information sources and subject specialists for the purpose of enhanced student learning.

Thus, each of the levels of the Maturity Model emphasises developmental stages that focus on different student learning opportunities. This unique aspect of the model encourages staff and management to make efficient use of available resources to maximise student learning. The Maturity Model has been designed to discourage some poor practice, for example installing high-speed Internet infrastructure without a proper support environment, or under using installed infrastructure by not linking technology use to subject-specific pedagogy.

Further research is required to assess the applicability of the model in other countries. An investigation of the model in other low-income countries would enhance confidence in its applicability. Examining the model in the context of institutions in middle-income countries would be expected to shed more light on the process of mainstreaming ICT in teaching across the full range of subjects taught. The Maturity Model does not currently pay sufficient attention to learning support technologies such as e-libraries and e-learning software applications, online social networking and cloud-based applications and services. Expansion of the model in these areas would be helpful, particularly for institutions that have already achieved Level 3.

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