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An Analysis of e-Learning Impacts & Best Practices in Developing Countries

With Reference to Secondary School Education in Tanzania



October 2011

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The ICT4D Program, 209 Communication Arts & Sciences Building

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U N I V E R S I T Y

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The Information & Communications Technology for Development (ICT4D) Program at Michigan State University (MSU) conducts research, teaching and outreach related to the role of ICTs in fostering economic, social and environmental change. Since 2008, it has been partnering with the University of Dodoma and the University of Dar es Salaam to build a sustainable broadband network and solar powered computer systems in schools in Tanzania. It is also conducting research and outreach programs in India, Malawi and other African countries, and in underserved communities in rural and urban Michigan. The ICT4D program offers undergraduate and graduate level courses, an undergraduate specialization, a study abroad program in Tanzania, and research and outreach opportunities in engineering and telecommunications. <http://tism.msu.edu/ict4d>

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The College of Education at MSU offers several graduate programs focused on the use of technology in education, including the Educational Technology Certificate Program, the Teacher Endorsement Program, a Masters of Arts in Educational Technology, and a PhD program in Educational Psychology and Educational Technology. These prepare teachers, administrators and other educational professionals for the use of technologies to support teaching and learning drawing on current theories of learning and development. <http://edutech.msu.edu/>

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Executive Summary

Objectives of the Study

This study has been conducted under a contract with the Tanzanian Education Trust (prime) and the MasterCard Foundation (sponsor) to provide information regarding the potential of e-learning to impact learning, society and the economy in developing countries with a particular reference to secondary schools in Tanzania. This paper also discusses e-learning solutions and challenges, and presents case studies and best practices of e-learning programs.

Approach

This study consists of a review of studies undertaken over the past fifteen years on education, e-learning and Information and Communication Technologies (ICT) in Africa, in other developing countries and, to provide additional context, in the U.S. In the study, we seek to provide a global and regional context to address the above objectives. Where ever possible, publications presenting results of empirical research are consulted. Research documenting the impact of e-learning in developing countries is, however, in its infancy due to the newness of programs. The study is informed by the authors' over ten years experience implementing e-learning programs and conducting teaching training programs in East and North Africa, and in the Middle East.

This study presents aspects related to e-learning solutions including the educational context of e-learning and pedagogical principles which inform e-learning approaches, examples of e-learning approaches and technologies, and the rapid changes being experienced in educational systems. It then provides a summary of what is known about the impacts of e-learning on education, the economy and society. Issues such as gender, the impact of e-learning on the workforce, and impacts on educational attainment are discussed. Finally, case studies and key best practices are provided.

Main Findings

Improving secondary education in Africa and other developing countries had until recently been overshadowed by programs focusing on national economic and infrastructure development. Recently, however, important investments by governments and donors are being made to expand the number of schools and student enrollment including in secondary education. In conjunction with this, the modernization of secondary education to produce a workforce capable of leading countries into globalized, knowledge-based economies has become a key goal. Many new policies and projects have begun to introduce information and communications technologies and related teaching approaches, known collectively as electronic or e-learning, into schools.

The expectations for these projects to affect student achievement and national economic development are often high. They are being introduced into educational systems that are experiencing critical challenges such as poor infrastructure, a lack of teachers and learning material, and poorly prepared students. The key question is how e-learning approaches can help address these challenges, and provide students a leap forward in their school learning and in their future employment opportunities. e-Learning programs in Africa and in other developing countries are still often small, experiential pilot projects with little documented history of their successes and impacts. Nevertheless, a body of literature is emerging that analyzes e-learning programs.

Integrating e-learning into existing educational systems

Educational systems are thus looking to e-learning programs to help address these challenges and to substantially improve the quality and content of their education. Integrating e-learning into existing secondary educational system can, however, be a major challenge. Secondary educational systems in developing countries are undergoing rapid change, particularly an increase in the number of schools and rise of student enrollment related to the recent emphasis of universal primary education. A consequence of this development, being experienced in Tanzania and elsewhere, is a significant shortfall in the number of teachers, particularly subject-specialty teachers, a declining student/teacher ratio, a lack of learning materials, and declining or stagnating test scores. Infusing technology into this context could be powerful method to partially address these shortfalls (see below).

Investment in e-learning is, however, not an alternative to investment in education generally; the two should be seen as being complementary. Integrating e-learning programs into existing educational systems can promote, however, a transformation. Implementing a comprehensive e-learning program would mean changes to the curriculum, infrastructure, teacher professional development, textbooks, and exams. A major benefit of integrating e-learning into governmental educational systems would be, however, a long-term commitment to growing and maintaining the program, with fewer e-learning initiatives ending when donor funding stops.

Many studies of e-learning programs have concluded that the key to ensuring successful outcomes is to blend more traditional classroom approaches with those that use technology. e-Learning approaches should be treated as a powerful tool that teachers can use, but teachers need to learn how student learning changes with e-learning, and how to alter their teaching methodologies with pedagogical approaches that take advantage of the opportunities afforded by e-learning. A blended approach mixing face-to-face classroom methods with technology-mediated activities seems to provide the highest learning outcomes. In African countries where secondary teachers have little prior experience with computers or similar technologies, all this can be a significant undertaking. In-service and pre-service e-learning teacher training programs have been designed and tested, however, with these goals in mind.

The potential of e-learning

e-Learning is a broad term that encompasses many teaching approaches, types of technologies and administrative practices. A challenge in analyzing e-learning is that the technologies and their educational applications are developing extremely rapidly. An additional challenge is that its newness and the excitement around their utility are leading to many suggestions for how to use technologies in and outside of the classroom. Nevertheless, the paper summarizes some e-learning solutions that have been applied and tested in developing countries. Some of the important potential contributions of e-learning programs in such educational systems include:

1. Addresses the shortage of teachers, especially science and other specialty teachers. It can do this by providing high quality teaching materials, such as videos, interactive software or information from a “cloud” on the Internet or a local computer. In a distant classroom or video conferencing approach, the number of students who receive live instruction from teachers in specialty subjects can be much larger.

2. Addresses the shortage of learning material such as textbooks for students. The material could be made available on hand-held devices such as e-readers or mobile phones. Interactive features such as quizzes or games could improve the level of learning and understanding.
3. Improves the quality of education by providing improved informational content and learning approaches. Interactive, communicative e-learning may promote the development of skills in students (so called “21st Century Skills”) such as critical thinking and problem solving, communication, collaboration and creativity.
4. Provides students information and communications technology skills. The graduates will be better equipped to contribute to the knowledge-centered globalized economy of their countries.

The impact of e-learning

The potential of e-learning to significantly affect education in developing countries is thus significant. Identifying the actual impact that e-learning programs have had on students, schools and their countries is, however, difficult. Because of the newness and diversity of the programs and the complexity of factors affecting outcome, measuring e-learning’s impact is an emerging science. Nevertheless, some direct and indirect outcomes can be discerned. They are presented below by e-learning’s impacts on students, teaching, the economy and lastly on society.

1. The impact of e-learning on student achievement is complex and mediated by a range of other factors affecting achievement. It is clear, however, that:
 - a. Their effectiveness is closely related to how the technology is used as an educational tool. Students learn best with e-learning when interactively engaged in the content. Using technology can motivate students, particularly under-achieving students, to learn.
 - b. Teachers report that tutorials in subjects such as math and science significantly improve student performance. Word processing software improves writing skills.
 - c. Providing technology on its own has little impact on achievement. Substantial effort must be put into infrastructure, teacher training, curriculum development, assessment reform, and formative evaluation.
2. The effect of e-learning on teachers and teaching parallels that of students. It includes:
 - a. The pedagogy often shifts from a teacher - centered classroom environment to a more learner - centered environment, allowing more effective use of technologies.
 - b. Teachers report that they gain confidence, self-esteem and renewed motivation in e-learning environments.
 - c. There are significant barriers to teachers in developing countries that need to be overcome including their lack of ICT skills and ICT-related pedagogical skills.

3. The economic impact of e-learning can be examined by first, identifying the impact of e-learning and improvements in education on the workforce and employment, and second, the effect of a high tech workforce on the national economy.
 - a. An improvement in education positively affects economic growth, both in terms of an increase in GDP and an increase in income for workers. This is clear in both developed and developing countries.
 - b. As technology and knowledge spillovers are the foundations of modern economic growth, it is important to ensure that the workforce has the skills to meet the need of these 21st Century jobs.
 - c. The average increase in annual income for each additional year of schooling, especially secondary education, for an individual is 10%. The affect is stronger in developing countries than in developed countries.
4. The impact on society of e-learning programs is similarly difficult to separate out from the multitude of other factors affecting society. The potential impacts of e-learning—providing underserved-groups access to quality education, for example, can be important. What is known about the impacts in developing countries include:
 - a. The “digital divide” between those people and countries with access to digital technologies and those without, is narrowing as information and communications technologies become increasingly available and less expensive. African countries are catching up fast, but from a lower base than other developing countries. Some of the widest digital divides are within countries: between rural and urban centers, and between rich and poor communities. This is unfortunately parallel to statistics of student enrollment in secondary schools. e-Learning has the potential to address this gap by bringing quality education to rural and other underserved schools, but poor infrastructure and other challenges are greater in those areas than in the better served urban areas, and experience to date is that these areas are underserved with e-learning as well. e-Learning programs that overcome these challenges thus have the potential to have large impacts on learning.
 - b. e-Learning technologies could potentially play an important role in reducing the gap in access to education and in achievement by girls and other underserved communities in developing countries. Currently, the gap in access to education of girls and underserved students is mirrored by a gap of them using the Internet and other ICT technologies, partly due to societal norms and partly due to their economic situation. Introducing e-learning technologies into schools can assist girl and other underserved students improve their ability to participate and thrive in schools. Governments and international organizations are designing e-learning programs to deliberately address the gender gap.
 - c. Language proficiency can be an impediment for students and teachers to take full advantage of e-learning’s benefits. Off-the-shelf educational software and most websites are in English or another global language, and students in Tanzania and

elsewhere whose main language is not a global language may need to become proficient a second (or third) language. The ubiquity of English on the Internet has been found to be a strong motivator for young people in many countries to learn English. In schools where a global language is not the language of instruction, however, it is important to customize educational software.

- d. The prevailing pedagogical culture in countries mediates how e-learning is adopted. In Eastern countries, for example, e-learning approaches run against educators' preferences for expositive teaching and authoritative delivery, in which case computers are simply used to deliver content. The potential transformative role of e-learning to develop 21st century skills in many countries may require, thus, integrating e-learning into the system from curriculum development to teacher professional development.

Taking advantage of e-learning's potential

Despite the numerous e-learning models and technologies available, a few key, common elements in successful e-learning programs have emerged. Case studies and the literature provide clues to what has and has not been successful. For example, countries that successfully integrated a sustainable e-learning have executed a multi-level program from the national policy level to the classroom that included developing e-learning related curriculum, teacher standards, and infrastructure.

Case studies and the authors' experience indicate that there are some particular activities in e-learning programs that are remarkably successful and encourage educators to sustain and expand their use of e-learning. The activities that have been found to work well include:

- 1) the full integration of e-learning into the curriculum, textbooks and tests
- 2) a strong program of training teachers to both use and teach with technologies,
- 3) the establishment of a pedagogical foundation for e-learning to assist teachers in integrating it into their teaching
- 4) providing ongoing support for teachers
- 5) educators joining a community of practice.

Concluding remarks

The goal of improving the educational quality and economic impact of secondary school education is coming to the front in many developing countries as their efforts to expand the number of schools and students are bearing fruit. Improving quality and gaining impact is, however, perhaps more difficult as it may require a transformation of the educational system itself. Many countries in Africa and elsewhere are turning to e-learning programs to assist with this transformation, and to fill some immediate gaps in their schools such as a lack of teachers and learning materials.

This report represents a collation of informational resources that document the potential of e-learning in developing countries, factors affecting its impact on education, the economy and society, and what experience has shown to lead to a successful integration of e-learning into educational systems. It discusses the non-insubstantial challenges related to introducing e-

learning into classrooms in developing countries, and issues related to change management in the institutions. Despite the complexities, however, the authors feel that enough has been learned from a pedagogical, technical and socioeconomic perspective to be able to design a successful e-learning program that methodically addresses the challenges, and that provides a platform for e-learning's transformative effect.

I. Introduction

Improved, modern education in developing countries provides the promise of meaningful employment for graduates, movement towards a knowledge-based economy, and rapid national economic growth. For this reason, parents, governments and donors are investing heavily in education. This building of the physical infrastructure as well as the knowledge infrastructure base such as teacher training, teaching materials and Internet facilities are necessary before the full benefits of the educational investments can be realized. Meanwhile, African countries lag behind other developing countries in educational attainment and other aspects of the human capital development required in our knowledge-based, global economy. Secondary school enrolment rates are, for example, 50 percentage points below other developing country averages. New programs in Africa promoting universal primary school enrollment are leading to increased demand for secondary schools, and a rapid expansion of secondary schools and students. The time to equip these secondary school students and schools with a strong knowledge infrastructure base for a knowledge-based economy is thus now.

Indeed, Africa has recently been leapfrogging communications technologies at a level and pace unlike any other continent. This rapid adoption may be partly responsible for the “African renaissance” and recent rise in economic growth rates. The rapid rate of adoption of cell phone technology among even rural and poor regions, for example, has been a surprise. It is providing new prospects for rural and other disadvantaged areas and people.

This phenomenon brings hope to the possibility of schools being able to use new technologies to leapfrog over many of their problems such as a shortage of teachers, school books and low achievement levels, and to train their students in technologies and to have “21st century skills” such as creative thinking and problem solving. e-Learning may assist with this transformation. The term “e-learning” originates from electronically-assisted learning, or learning with and through the use of technologies. Other commonly used terms include online learning, computer-assisted learning or ICT in education. e-Learning incorporates both content (curriculum) and instruction (pedagogy). e-Learning has become a term representing a new model of education that may incorporate an “ecosystem” of networked communities and a variety of learning resources.¹ In education, it involves revised curriculum, infrastructure, teacher professional development, textbooks, and exams (e.g., Uden, Wangsa & Damiani, 2007).

This paper discusses these issues in developing countries with a focus on Africa. It provides examples with information from Tanzania, a country that is at the cusp of transforming its secondary school educational system including incorporating e-learning. The situation of Tanzania reflects many countries in Africa and elsewhere that are changing rapidly, and where the government, citizens and international institutions see opportunities to help shape its future in exciting directions.

This report provides a summary of e-learning solutions available, and discusses the potential and challenges of teaching and learning with these approaches in a developing country context. It then summarizes what is known about the effect of e-learning on education, economics, and

¹ “A digital ecosystem is a self-organizing digital infrastructure aimed at creating a digital environment for networked organizations that supports the cooperation, the knowledge sharing, the development of open and adaptive technologies and evolutionary business models” (p. 114, Uden, Wangsa & Damiani, 2007).

society. Finally, it provides some case studies and summarizes what has been found to be key components of successful programs.

II. E-Learning Solutions

A. Pedagogical Principles and e-Learning

“Research suggests that simply putting computers into schools is not enough to impact student learning. That said, specific applications of ICT can positively impact student knowledge, skills and attitudes, as well as teaching practices, school innovation, and community services (pg. 1, Kozma, 2005).”

The concept of e-learning integration into an educational system begins with the teacher and the ways in which teachers teach. This section thus starts with pedagogy – the art and science of teaching children. The academic approach to this subject discusses the theoretical perspectives of behaviorism versus constructivism and, for the purposes of this paper, how they apply to a technological secondary school classroom. A simplistic description of the view is that of “chalk and talk” and the teacher as the ultimate authority and purveyor of knowledge – the “sage on the stage”. This compares to the constructivist model or method where students work collaboratively and socially construct new knowledge. In a technological classroom there will most likely be elements of both perspectives blended in a way that makes teaching comfortable for the teacher and takes advantage of new tools and opportunities.

The challenge for many if not most teachers, particularly in developing countries, is changing their practice of teaching in ways that accommodate the use of technology. Blending how they have traditionally practiced teaching with the use of technology beings to create e-learning solutions. In e-learning, technology is simply a tool that educators may use in a number of ways within the new environment that can impact student learning and outcomes.

A teacher deciding to use technology needs to consider how it may provide a solution to a particular problem of practice they have within their learning environment. An example of addressing a problem of practice could be the use of e-readers to address a lack of textbooks. Another could be how to help children understand “big ideas” or concepts in science education. A third could be helping students, working alone or in groups, to use computer simulations to manipulate the environment and immediately see the outcomes. Rather than just being told about a certain theory, they can experience the theory, which enhances their learning and enables them to retain the concepts for longer.

1. Conceptualizing Technology in Relation to Teaching

In this blending of technology, pedagogy, content and knowledge, a theoretical principle has evolved known as TPACK which reflects the intersection among three domains of teacher knowledge: content, pedagogy and technology (Mishra & Koehler, 2006, 2008)². Research has shown that teachers can move from seeing content, pedagogy, and technology as independent

² This conceptualization draws heavily on the work of MSU faculty Mishra and Koehler, for example, as published as the keynote chapter of the 2008 AACTE *Handbook of Technological Pedagogical Content Knowledge for Educators*. For additional resources on TPACK, see <http://tpack.org> and <http://www.mendeley.com/groups/522011/tpack/>.

domains of knowledge to recognizing the transformative potential of the interdependence among the three domains. In this framework, the starting point is an analysis of both the complexities of teaching and the nature of technology. The framework was developed as an extension of Shulman's influential conceptualization of pedagogical content knowledge. The conceptualization highlights what good teachers know about how to teach a particular subject matter in addition to their knowledge of what to teach.

In considering the relationship between technologies, pedagogy, and content, it is important to explore how teaching and learning can change as the result of using a particular technology. For example, the use of inexpensive digital cameras or cell phones with integrated cameras can shape decisions about content and pedagogy. Students can use these cameras to build their own bridges between content within the school environment and their daily lives. Students can explore the presence of geometric shapes in places that teachers would not have anticipated, thus creating their own applications of the ideas being taught in the classroom. Inevitably students will find new connections that teachers (and project designers) did not anticipate, connections that feed their natural curiosity and honor their contributions to the learning environment..

Communities of Practice. Experience suggests that teachers most readily adopt and adapt technology when they join a community of practice under the guidance of mentors. This involves them in inquiry and problem solving, anticipating the complexities with which teachers and learners are faced and the need to enable teachers and students to respond flexibly and creatively. Participants learn about technologies when and only when they need these technologies to complete their projects rather than being taught technologies in case they may someday have opportunity to use them.

A central strategy is thus to create communities of practice among educators. The importance of a grassroots approach has been repeatedly shown by research. It builds on collaboration and community building at all levels, and lowers the levels of resistance compared to when authorities simply mandate ICT use. When teachers and other educators work within their peer groups, the rate of adoption is much higher.

Teacher Networking. Mobile or internet-based networks will provide a critical impetus for teachers and mentors to use the computers in a creative and thoughtful mode, to try new approaches, and to communicate their successes and challenges. These networks have the dual advantage of 1) promoting information exchange among teachers and mentors that is interactive and tailored to individuals' needs, and 2) stimulating the use of ICT by teachers for purposes that go beyond simple cookbook applications. Research indicates that teacher networking significantly increases the interest in and use of new technology and other pedagogical approaches.

2. ICT as a Tool to Foster Learning

To foster learning through the use of technology, it is useful to examine the pedagogical principles behind teaching and learning with ICT. Technology is a powerful and effective tool, but if teachers use it only as a delivery vehicle, the outcomes will be less than its potential. The challenge is to make full use of technology so that it doesn't become simply a substitute teacher. Indeed, instructional content can be embedded in the technology and then delivered to the

student with the assumption that if you deliver content the students will learn. But by blending the use of technology with teaching by the teacher, students have been shown to have much higher learning outcomes.

Technology should thus be used as an engager and facilitator of thinking and knowledge construction. Useful roles for technology to support effective pedagogy include (Jonassen, Peck, Wilson 1999):

- Technology as tools to support knowledge construction:
 - For representing learners' ideas, understandings, and beliefs
 - For producing organized, multimedia knowledge bases by learners.
- Support learning-by-constructing:
 - For accessing needed information
 - For comparing perspectives, beliefs, and world views.
- Technology as context to support learning-by-doing:
 - For representing and simulating meaningful real-world problems, situations and contexts
 - For representing beliefs, perspectives, arguments, and stories of others for defining a safe, controllable problems space for student thinking.
- Technology as social medium to support learning by conversing:
 - For collaboration with others
 - For discussing, arguing, and building consensus among members of a community
 - For supporting discourse among knowledge-building communities.
- Technology as intellectual partner to support learning-by-reflecting:
 - For helping learners to articulate and represent what they know for reflecting on what they have learned and how they came to know it
 - For supporting learners' internal negotiations and meaning making
 - For constructing personal representations of meaning for supporting mindful thinking.
- Technology as information vehicles for exploring knowledge.

The US Department of Education (1998) developed a simple visual that has become standard of the basic changes that occur in a shift from traditional to e-learning (Table 1). These are the basics behind teaching students what has become known as 21st Century learning and innovation skills (critical thinking and problem solving, communication, collaboration and creativity) (Partnership for 21st Century Skills, 2009).

Table 1. Traditional and New Learning Environments. Source: DOE 1998.

Traditional Learning Environments	New Learning Environments
<ul style="list-style-type: none">• Teacher centered instruction• Single sense stimulation• Single path progression• Single media	<ul style="list-style-type: none">• Student centered instruction• Multisensory stimulation• Multipath progression• Multimedia
<ul style="list-style-type: none">• Isolated work• Information delivery• Passive learning• Factual, knowledge-based• Reactive response• Isolated, artificial context	<ul style="list-style-type: none">• Collaborative work• Information Exchange• Active/exploratory/inquiry based learning• Critical thinking and informed decisions• Proactive / planned action• Authentic, real-world context

Considering the relationship between technology and pedagogy thus leads to understanding how teaching can change as the result of using a particular technology. As such, new technologies encourage teachers to confront basic educational issues in new ways. The range of e-learning technologies and their uses are described in the following section.

B. e-Learning Solutions

1. Approaches to using Technologies in e-Learning Classrooms

e-Learning is a thus broad term that covers teaching, learning and the enabling educational environment. It can use a range of pedagogical approaches and electronically supported technologies. Some examples of using technologies in e-learning classrooms are below:

- One-to-Many (communication between the teacher and the class as a whole):
 - Online classes. Content can include lecture notes, assignments, message boards, linked bibliographies of readings and websites, quizzes, and chats
 - The viewing of TV shows, videos or other previously prepared material at a central location
 - The teacher in a multi-media classroom projecting content using a projector or screen, or using an interactive whiteboard. The content can range from PowerPoint slides, news broadcasts, interactive websites, the teacher drawing graphics, to educational software demonstrating a virtual chemistry experiment.
 - Distant learning classroom or video-conferencing, in which a teacher is broadcast live to a single or to multiple remote classrooms. The distant rooms can communicate to the teacher and others through text or audio chatting, or video.
- One-to-One (student and teacher communicate)
 - Teachers monitors individual student activity and progress using a feedback program
 - Teacher reviews assignments, questions, has office hours.

- One-Alone (student alone with course content, self-paced)
 - E-reading devices with textbook or other reading material
 - Interactive lessons, exercises, quizzes, games or other software that a student accesses through a computer, mobile phone, tablet or other. Applications may predict and suggest content based on student behavior and progress.
 - Student conducted research, writing and other homework preparation on a laptop or other computer.
- Many-to-Many (students communicate among themselves)
 - Students communicate in a class discussion group, share information or communicate with people outside the classroom
 - Student group presentations.
- Teacher Training
 - Teachers access training materials, exercises and take tests using online or hosted material and software
 - Teachers form a “community of practice” to share experiences, get ideas in a social media type of environment.
- School Administration
 - Learning management system
 - Computer aided assessments (tests, grades).

This list of possible approaches using technology in learning and teaching must, again, be placed into an educational context (Koory, 2003). There are no conclusive research results for the US much less developing countries indicating that one type of e-learning approach is more effective than another, or that strictly online learning is more effective than strictly face-to-face learning. However, recent large, meta-analyses have found that learning outcomes are somewhat improved with a “blend” or hybrid of face-to-face learning with a teacher combined with technology-mediated learning (e.g., Means et al., 2010; Roblyer and Doering, 2009). A combination of approaches and content type is best. Pedagogical principles also impact the effectiveness of e-learning especially for K-12 students—e-learning is enhanced by giving students control of their interactions with the media, by embedding feedback mechanisms. When the software triggers student activity such as reflection or self-monitoring, there is a positive impact on learning. This holds true when students are working as individuals but not necessarily when in groups (Means et al., 2010).

Each of the approaches described above could be accomplished using various e-learning settings in schools, and using different technologies. Below is a summary of these school settings, followed by a brief description of technologies available.

2. e-Learning Technologies and Configurations in Schools

There are many e-learning settings and technologies available to use in schools, each with their own advantages and applications. Often the best solution is a combination of technologies depending on the particular need and learning environment.

Multimedia Classroom

In a multi-media classroom, educational content is delivered to students in a one-to-many approach. This is cost efficient per pupil, and can provide a large amount of educational resources to students. Classrooms would be equipped with a projector, screen (or large LCD), speakers and a classroom computer. The teacher could display various types of content that is housed either on the classroom computer or on the teacher's laptop or other device. The teacher would be able to adapt and project various content (e.g., videos, Powerpoint slides, augmented reality, multimedia presentations, the teacher drawing a graph, etc.). A connected classroom would have wireless or wired communications to a "cloud" of resources. The teacher would thus have access to a wide range of content from the library on the cloud. The computer housing the content could be locally based at the school (which would obviate the need for inter-school communications, and be reliable), at a district or national educational headquarters, or elsewhere.

Connected multi-media classrooms would permit distant classroom teaching, in which a teacher in one school or from a studio could deliver live, interactive lectures to classrooms in other schools. The distant classrooms would need to be outfitted with video cameras and microphones, as well as projectors and speakers, to communicate with the distant teacher.

Computer Lab

A computer lab is among the most recognizable form of e-learning technologies. A computer lab usually consists of many single personal computer stations. This is a common arrangement found in schools throughout the world. There are many educational software packages available that could be installed for student use. Separate stations permit individual students to move at their own pace through material. Teachers can also lead students or student teams through guided exercises, with each following on their own station. Free computer time itself is a valuable educational resource.

Installing separate computers is an easy to set up, since it is simply single stations behaving independently. Computer labs can be, however, more expensive per student due to the individual computers and software licenses. They may also have higher power consumption demands, depending on the computer or device, necessitating low-cost power solutions.

Multi-seat computing consists of using one powerful personal computer with extra video cards to support up to eight independent "seats" (each with its own monitor, keyboard and mouse running separately). They can be put in a computer lab for students or teachers to use, or in classrooms. There are several commercially available multi-seat operating system software options including by Microsoft and Linux. This system has the advantage of using much less power than other options. It is usually the least expensive per user as well.

Single Station, Personal Computers

A variety of types of single station devices are available.

- 1) *Personal computer (PC)*. A PC is a common approach for using computers in homes and offices. It consists minimally of a computer, one or two monitors, a keyboard and mouse. Each computer has its own operating system and software programs. From a setup and maintenance standpoint this type of system is advantageous. It is easy to maintain and does not generally require a specially trained computer technician to fix most hardware

and software problems. However, if each student were to have a computer, this would be among the more costly options to implement, particularly in rural areas reliant on solar power. This would be useful particularly for teacher stations or single stations in the back of classrooms.

- 2) *Micro Computer.* A microcomputer is similar to a standard single station except that it uses a small form factor case with a generally slower processor. Power consumption can be much lower than a single station, and thus suitable when power is limited. The computers are, however, difficult to repair and may be prone to theft and overheating; the lifespan of these devices is not yet known. Software maintenance is similar to a standard single station.
- 3) *Laptop or notebook.* Laptops and notebooks are among the easiest educational solution to set up. They usually come with software preinstalled and only a power outlet is needed to begin using the system. The power consumption is low compared to a personal computer. Hardware maintenance can be difficult, but software maintenance is standard. One of the disadvantages is product lifespan; they are easy to steal and are prone to accidents (a spill on the keyboard can easily destroy it; new rugged laptops reduce this risk). New design and battery technologies are lengthening battery life in some machines. Laptops may be an excellent solution for teachers. Teachers could bring a laptop to work from home, and then connect it to the classroom projector.

Small, Personal Devices

Small, personal devices such as tablets, smart phones and e-readers are similar in that they are all relatively new technologies. They are rapidly gaining popularity due to their declining price, large number of web-based software applications, powerful graphics, and enjoyment of use. Educational uses could include listening to audio lessons or audio books, gaming, watching videos, and reading. Writing is more difficult if the device doesn't have a keyboard. Schools and teachers can develop teaching material applications for mobile devices using existing software. An example of how rapidly this is occurring is that over 10,000 pieces of content (learning materials) for U.S. schools are already available from one education company (Study by App). As discussed in the ICT section above, penetration of mobile cellular Internet is rising rapidly in Africa and other developing countries because of the availability and relatively low cost of Internet access, text and voice through cellular networks, especially compared to broadband Internet. Because of this, the World Bank, USAID and other donors are actively investigating the potential role of mobile phones and e-learning devices in education in Africa (World Bank 2011; USAID 2011).

Nevertheless, the maintenance requirements and lifespan of smart phone and other small devices in difficult environments are not yet known. Similar to laptops, they can be easily lost or stolen, and are prone to accidents. A difficulty in adapting educational software is that the various brands and styles have different operating systems and screens, and each may require separate configuration. Their batteries need to be frequently recharged, but individual external solar panels could be used. The cost of Internet or telecommunications time for teachers, students or schools may also be a limiting factor. Some of these challenges are being addressed by private companies and others who are designing engineering solutions and new software for the devices.

1. *Tablet.* A tablet personal computer is similar to a laptop but with a touch screen, and often a smaller hard drive and screen. Tablets may or may not have a keyboard. A touch screen permits a new form of human-machine interaction, the uses for which are becoming increasingly apparent. As educational software is developed to take advantage of touch screens, tablets may become useful for e-learning.
2. *Mobile Phone/Smart Phone.* Today, cellular Internet coverage is often available, even in rural areas (especially compared to broadband). With the rapidly declining cost and increasing features of mobile phones, there is potential to use mobile phones as a web-based e-learning technology. They can also, for example, be used by students in the classroom as a virtual clicker (to answer questions teachers ask in class), or for games or quizzes by using text messaging interfaced to an instructor's computer or phone. They may be used as an e-reader, or for communicating with other students or teachers.
3. *E-Readers.* E-Readers are becoming popular as a relatively low-power, inexpensive replacement for traditional textbooks. Their purchase price is declining. One e-reader could contain multiple textbooks or other readings, and the content could be easily updated. E-readers often have high resolution, monochrome screens making them good for reading text but not for multimedia applications. Where books are expensive, hard to find or need to be frequently updated, e-readers may be very useful. It would be easy to upload in-class "handouts" to student e-readers as well. Copyright agreements and revenue sharing would need to be arranged with the book's publisher.

C. Transition Towards e-Learning in Developing Countries

To meet the promises and potential of e-learning in developing countries, many challenges must be addressed in its implementation. These include underlying economic, governance and infrastructure problems, and difficulties faced by the educational systems themselves. At the individual country level, investments in primary and tertiary education in developing countries continue to be low relative to the need. Only a few African countries allocate more than five per cent of their budgets to education (ITU 2011b). However, many countries are now implementing ambitious strategic frameworks to support their human capital initiatives. These are often focused on areas such as social inclusion, the health of school age children, nutritional support, programs to support girl education, and modernization of the curriculum including technology skills. If not addressed, the challenges existing in schools, however, could restrict the e-learning technologies' effectiveness and particularly their sustainability in schools over the long term. The following section briefly describes the challenges that many educational programs are facing and how e-learning and ICT initiatives are expanding despite these. Indeed, e-learning and ICT are being employed in some cases to address these challenges.

1. Growth in Information and Communications Technologies (ICT)

e-Learning and information-based technologies are all based on the sharing of information and knowledge through the Internet or other communications systems, collectively known as Information and Communications Technologies. Access to communications technologies is, thus critical for e-learning and related educational and economic success. African countries, however, have a comparably weak physical and knowledge infrastructure base, exacerbated by poor

computer, telecommunications and Internet facilities (Annex 1). The lag in the development of computer and ICT infrastructure within Africa and between Africa and other developing countries has the danger of increasing their exclusion from the global economy. The reasons for the low levels of facilities and skills are often attributed to: 1) low per capita income levels, and 2) low levels of knowledge and physical infrastructure (Oyelaran-Oyeyinka and Lal 2005).

However, Africa has recently been leapfrogging communications technologies at a level and pace unlike any other continent. This rapid adoption may be partly responsible for the “African renaissance” and recent rise in economic growth rates. The rapid rate of adoption of cell phone technology among even rural and poor regions, for example, has been a surprise. African countries are among the leaders in developing innovative uses of the cell phone, such as the current use of cell phones in East Africa for banking, wireless Internet and other informational services. Approximately half of the population in Tanzania, for example, already owns a cell phone, and voice network covers most of the country. This is providing new prospects for rural and other disadvantaged areas and people. It provides a growing opportunity for new educational approaches that have direct economic and social development impacts to meet the requirements of an increasingly globalized society (UNCTAD 2007).

Although the mobile sector is important, other communications technologies, such as broadband Internet, computers and the host of related information products and services commonly available in developed countries, have thus far lagged.

2. Transitions in Educational Systems

African countries lag far behind other developing countries in educational attainment and other aspects of human capital development required in an increasingly knowledge-based global economy. Data indicate that secondary school enrolment in African countries averages only about 30%, compared to 65% for developing countries worldwide, and close to 100% in East Asia. Education quality in most cases is not where it needs to be, either, with outdated curricula. Meanwhile, in middle-income economies, quality and quantity of secondary and tertiary graduates are among the driving factors behind economic and social performance (Verspoor 2008). The indicators suggest that African countries are falling behind other developing countries in spite of the significant progress in access to education made since independence. The vast majority of the population is either rural based, or recent migrants to urban areas. The degree of economic retrogression in these countries during the past few decades, and the lag between these countries and other developing countries in terms of the stock of human capital, is likely to widen in the face of the rapid advances in science and technology in the more developed societies (Oyelaran-Oyeyinka and Lal, 2005).

Tanzania can be used as an example of how governments have responded to the need to improve educational attainment of their citizens by transitioning their educational system. The Government of Tanzania is currently implementing an ambitious policy to rapidly increase the number of secondary schools throughout the country (Table 1 and Annex 3). This increase, almost a doubling from between 2004 and 2008 to now around 4,000, has occurred without sufficient numbers of new teachers or other educational resources. A declining teacher to student ratio, from 1:23 to 1:37, occurred in only four years. Schools have reacted by having larger class sizes, by rotating teachers (having classes work without teachers), and by sharing trained

specialty teachers between schools (teachers travel between schools). Shortages of trained specialty teacher are particularly severe in subjects such as math, physics, chemistry, science and English, all vital subjects for Tanzania's economic growth.

Table 2. Secondary School Education Enrollment and Performance in Tanzania, 2004-2008.
Source: Ministry of Education and Vocational Training.

Table 2.1: Difference in Tanzania Secondary Schools Statistical Data from 2004 to 2008					
Description		2004	2008	Difference	%Increase
Enrolment (Form I-IV)		401,598	1,164,250	762,652	190
Enrolment (Form V-VI)		31,001	58,153	27,152	88
Total Enrolment (Form I-VI)		432,599	1,222,403	789,804	183
Enrolment (Teaching Staff)		18,754	32,835	14,081	75
Number of Registered Secondary Schools		1,291	3,798	2,507	194
Teacher-to-Student Ratio	Govt.	1:23	1:37	14 Students More	
	Non-Govt.	1:23	1:41	18 Students More	
Source: Basic Education Statistics in Tanzania (BEST) of 2008 from Ministry of Education and Vocational Training (MoEVT)					

Table 2.2: Situation of Form IV O-Level Performance from 2003 to 2007					
Division Obtained	Year				
	2003	2004	2005	2006	2007
I-III in %	38	38	34	36	36
IV and 0 in %	62	62	66	64	64
Total Number of Students Examined	62,359	63,487	85,292	85,865	125,288
Source: Basic Education Statistics in Tanzania (BEST) of 2008 from Ministry of Education and Vocational Training (MoEVT)					

Table 2.3: Form VI National Examination (ACSEE) Performance							
Subject	Pass Grade	Year					
		1999	2000	2001	2002	2003	2004
Physics	Grades A, B, and C in %	30	14	14	19	17	19
	Grades D, E, and F in %	70	86	86	81	83	81
	Total Number of Students Examined	2,480	2,580	2,954	3,154	3,300	3,534
Advanced Mathematics	Grades A, B, and C in %	24	21	22	19	23	39
	Grades D, E, and F in %	76	79	78	81	77	61
	Total Number of Students Examined	1,547	2,065	2,102	2,288	2,499	
Source: Basic Education Statistics in Tanzania (BEST) of 1995-2004 from Ministry of Education and Culture (MoEC)							

A summary of e-learning challenges secondary schools in Tanzania and in many other developing countries thus face include (Hennessy, 2010; ITU 2011b; Alemneh and Hastings 2006):

- Severe shortage of teachers, particularly in specialty science and other subjects
- Teachers insufficiently trained in their own subjects, and have little to no computer experience
- Large class sizes (average 60 students but often higher)
- Poorly equipped classrooms, dormitories and kitchens. Lack of teacher housing, especially in rural areas. Most rural schools are not on the electrical grid.

- Expensive and slow Internet connections. Very few schools have an Internet connection. Most schools with computers are not using them as a medium of instruction.
- Shortage of text books for students, and extremely limited teaching materials for teachers
- Reference books, labs, teaching and learning aids are in short supply
- Outdated curricula
- Students are often ill-prepared for the switch from learning in Kiswahili in primary schools to English as the language of instruction in secondary schools
- Declining enrollment of girls in each year of secondary school due to early marriage, safety concerns and family or social obligations
- School fees are often beyond the reach of poor and particularly rural parents
- Pass rates for the national exam are low and stagnant or declining
- Insufficient funding.

In response to these challenges and with the goal of improving educational outcomes and educating a workforce, the Tanzanian government is looking to the potential role of ICT. ICT along with other interventions is seen as providing an opportunity to enhance and improve quality of delivery of education, as stipulated in the *National ICT Policy of 2003* and the *Information and Communication Technology (ICT) Policy for Basic Education* in 2007 which incorporates the integration of ICTs in pre-primary, primary, secondary and teacher education, as well as non-formal and adult education (Hare 2007). *The Information and Communication Technology (ICT) Policy for Basic Education* addresses strategic use of ICT in teaching and learning as well as administration and management of schools. The Government, through the Ministry of Education and Vocational Training is thus implementing projects introducing ICT in government teachers' colleges, secondary and primary schools and its agencies. Integration of ICT technologies in schools would require significant pre-service and in-service teacher training in basic computer literacy as well as how to teach with e-learning technologies (Calder 2009). Meanwhile, in-service teacher ICT skills are low. A survey of teachers in secondary schools in northern Tanzania that the authors (DeMaagd and Olson) conducted showed that less than 10% had ever touched a computer. A table summarizing the enabling and constraining factors of ICT integration in Tanzanian schools is provided in Annex 2.

Although Tanzania is used as an example, its experience is common in other African and many other developing countries. Governments in many countries have ambitious plans to increase the percentage of children in schools, to improve the quality of education and rise achievement levels, and to modernize the system including with e-learning approaches.

3. Physical Factors Affecting e-Learning Technologies in Schools

In addition to educational system challenges, difficult physical environments and electrical power conditions in developing countries can exacerbate the implementation of successful e-learning programs and reduce the lifespan of technological devices. These conditions may include:

- Extreme heat, humidity, and dust. Materials corrode and equipment ages rapidly. Fine dust enters the inner workings of machines, and covers solar panels.
- School buildings: roof leaks, no ceilings, no glass in windows, lack of student desks, insecure.

- Pest problems—rodents chewing through Ethernet wires, insects entering computer housing, bees taking residence in the classroom, to cattle scratching themselves on communications towers
- Theft of and non-malicious (curious) tampering with equipment
- Relative isolation of many rural schools due to long distances and poor roads
- Electrical power: the electrical grid may be over-extended, and have frequent black outs. The power itself is fluctuating with frequent spikes and dips that can destroy computer and other equipment. Solar systems may be expensive to initially purchase, so low power draw by the system is critical.
- Broadband connectivity may be increasing in the near future to major towns and cities. In the meantime and outside urban centers, Internet can be accessed only through expensive satellite systems or cellular networks
- Computer viruses are often rampant, software is often pirated
- Shortage of trained ICT professionals particularly in rural areas to conduct the required, continual maintenance
- High cost of imported equipment and tools; repair and replacement costs can be high.

Some private and non-profit computer manufacturing companies and international institutions are addressing some of these environmental and educational challenges with the design of rugged and low-power technologies, and educational software (Annex 4). The environmental and technical problems are often a common cause of the breakdown and eventual abandonment of technologies in schools.

The authors (deMaagd, Olson and Tarkelson) as part of a team of faculty and students at Michigan State University, USA and University of Dodoma, Tanzania have been designing, installing and testing e-learning solutions in primary and secondary schools in northern Tanzania since 2008 to learn how to address these environmental and other challenges. The environmental challenges in northern Tanzania are common to those across other rural areas and towns. They include extreme heat and dust, no Internet connectivity, no or unreliable electrical power, pests and poor infrastructure.

To address these, a low-power, rugged and flexible system was designed and has been refined based on a solar-powered, multi-seat computer system. One personal computer serves six independent seats, reducing power consumption while permitting full PC software applications. Internet is provided by a solar powered central satellite dish and is linked to the other schools via a system of point-to-point Wi-Fi and Wi-Max, wireless technologies. In the schools on solar power, the system monitors and manages energy generation to maintain optimal efficiency. Mobile phones can be recharged on the solar system as well. In the schools on the electrical grid, power is regulated to guard the safety of the equipment and work of the users. Additional e-learning approaches, including tablet-style laptops and classroom projectors, are being tested. Teacher training, student involvement and content development have been a key part of the program. The systems are being used for various activities including social and professional networking, research, class preparation, class and school administration, tutorials and educational games. Computer clubs in the secondary schools have been extremely popular.

Lessons learned by the project include those related to addressing the environmental challenges such as energy efficient design, reducing the risk related to dust, heat and pests, the use of wireless technologies for medium-distance internet connectivity, and maintenance approaches. A critical aspect of the process ensuring continuity and growth, however, has been the involvement of district and school administrators, teachers, students, and community leaders and members in all stages of the project from initial planning decisions, to digging trenches for cables, to attaining computer training.

III. The Impact of e-Learning on Education, the Economy and Society

The necessity to become proficient in modern communications and information technologies, and the need to improve the quality of their education sector, have driven many African and other developing countries and donors to sharply increase their investments in e-learning. The impact of these investments on learning, on the economy and on society has yet to be quantifiably documented, partly due to the recent nature of the programs, and partly due to the newness of the ICT4D research field. Most literature consists of what could be expected from e-learning programs, or are small case studies that are difficult to compare. There have been important efforts to compare the rare empirical studies in meta analyses but the authors caution that there is as yet insufficient data or clear trends to make solid conclusions about the impact of e-learning on learning or societal factors (Hennessy et al. 2010; Means et al. 2010; Farrell and Isaacs, 2007; Hare, 2007). Nevertheless, this section will summarize the information that exists to describe some developments that e-learning is influencing.

A. Educational Impacts of e-Learning

This section reviews what has been found of the impact of e-learning on educational systems, and on students and the teaching practices.

From an analysis of several international ICT integration plans (IETE, 2011), the long run adoption of ICT into education systems has been successful when done as an integral and holistic component of education. Technology plans, whether they are at a national level or local level, need to address policy, curriculum integration, professional development, community engagement, infrastructure, and access. Today the approach is no longer simply putting computers in the classroom and connecting to the Internet. Indeed, a critical area at the system level to highlight is the pedagogical aspects of technology as a tool for learning, integrated into all aspects teaching and learning. Technology should become a student's intellectual partner, and the focus should be on how students learn with technology (Peck et al. p.12). Understanding how students learn with technology emphasizes the process of how teachers teach with technology.

Before investing in new ICT programs, it is key to decide on the main goals of the program. Authors of the SITES report on South Africa (Howie, Muller, & Patterson, 2005) noted that secondary school principals reported the following goals for their ICT programs:

- To prepare students for future jobs
- To improve student achievement
- To promote active learning strategies
- To individualize student learning experiences
- To encourage more co-operative and project-based learning

- To develop student independence and responsibility for own learning
- To give students drill and practice exercises
- To make the learning process more interesting and engaging.

These goals include using e-learning for more traditional efforts to improve student academic performance as well as newer objectives related to the development of technical and social skills important in the marketplace. Thus e-learning programs are expected to influence a broad array of skills, and due to their potential to affect the educational system—from pedagogy to curriculum—their integration needs to be done at multiple levels of the educational system.

1. Impact of e-Learning on Students

It is expected that the most direct impact of e-learning would be on the learning achievement of students. The results of large, cross-national studies show that the effects on learning are complex and closely related to how the technology is used as an educational tool, and other factors. Putting technology into a school is not the simple solution to improving learning. Kozma (2005) notes “the most pronounced finding of empirical studies on ICT impact is that there is no consistent relationship between the mere availability of ICT and student learning”.

Another author, Kulik (2003) conducted a meta analysis of studies to identify the impact of e-learning on student outcomes. He identified the following trends:

- Students who used computer tutorials in mathematics, natural science, and social science score significantly higher on tests in these subjects compared to students who did not use computers. Similarly, students who used simulation software in science also scored higher. However, the use of computer-based laboratories alone did not result in higher scores.
- Primary school students who used tutorial software in reading scored significantly higher on reading scores. Very young students who used computers to write their own stories scored significantly higher on measures of reading skills
- Students who used word processor or otherwise used the computer for writing scored higher on measures of writing skill.

These are similar to the conclusions of Means et al. (2010) who noted, albeit with many caveats as to the statistical strength of the relationship, that their meta-analysis showed that e-learning is enhanced by giving students control of their interactions with the device, by for example embedding feedback mechanisms. When the software triggers student activity such as reflection or self-monitoring, there is a positive impact on learning. They found that this effect holds true when students are working as individuals but that the impact is not clear when students work in a many-to-many group situation.

Indeed, an increasing body of literature shows that students learn best when they are actively engaged with the curriculum and content (McGraw Hill, 2011). Teachers are challenged to develop curricula of an exploratory nature that engages students with hands-on, inquiry-based learning. The results are students with higher levels of motivation and engagement. Computer based strategies help students develop higher-order thinking and problem-solving skills. Participation in real-life applications allows students to draw analogies, infer relationships, predict outcomes and analyze data.

From these and other studies, it is interesting to note that e-learning can also have a positive impact on less tangible aspects of learning, particularly student motivation. e-Learning affects student attitudes towards technology, instruction, and subject matter. Codde, an author of this white paper, made an interesting observation in a three-year program in Algeria that linked Algerian high schools with US high schools. He noted that lower achieving students were becoming more engaged in their learning. Their teachers reported improvements in other subjects as well. Similar observations were made in a study in Kenya in which two randomly assigned physics classes used computer-based instruction, whereas a third equivalent group did not. At the end of the lessons, students in the computer sections had learned physics concepts better and expressed more positive attitudes about their physics learning (Kulik, 2003).

One widely-promoted e-learning initiative in the US and globally is the one-to-one laptop program. Research on its effectiveness, although limited, is growing. Factors related to its success include teacher professional development, access to technology support, and positive teacher attitudes towards the use of technology and laptops in the classroom (Penuel, 2006). Not all the research is favorable, however. The most notable laptop project is Nick Negroponte's One Laptop Per Child (OLPC). For a project of this nature to succeed, whether it be in developing or developed countries, a substantial effort should be put into infrastructure, teacher training, curriculum development, assessment reform, and formative evaluation (Warschauer & Ames, 2010). Negroponte's approach has been to give every child a laptop, and then assume that students will learn even without the project implementing other elements shown to be important for successful e-learning programs. Although the project has succeeded in placing the topic of ICT in education and the needs of developing countries in the news, it has failed to accomplish its goal of putting laptops into the hands of millions of children around the world, including those in the most impoverished nations.

Positive elements of laptop programs in general are highlighted in research done by Gulek and Demirtas (2005) in their evaluation of Microsoft's *Anywhere Learning Project*. Their research demonstrated positive results on student learning and curriculum delivery. The evaluation of student and teacher outcomes are summarized below:

Student Outcomes:

- laptops lead to more student writing and to writing of higher quality
- laptops increase access to information and improve research analysis skills.

Laptop Students...

- spend more time engaging in collaborative work than non-laptop students
- participate in more project-based instruction
- become collaborators (interact with each other about their work)
- direct their own learning
- report a greater reliance on active learning strategies
- readily engage in problem solving and critical thinking
- consistently show deeper and more flexible uses of technology
- spend more time doing homework on computers.

Teacher Outcomes:

- Teachers who use laptops use a more constructivist approach to teaching
- Teachers who use laptops feel more empowered in their classrooms
- Teachers who use laptops spend less time lecturing.

According to Gulek and Demirtas (2005 pg. 6) and as reported by Rockman et al. (1997, 1998, 2000),

“...laptop use not only reinforces the utilization of successful learning strategies but also enables students to transfer the knowledge across disciplines. This is believed to occur because laptop students are involved in: (1) highly engaged and focused activities (spending more time on their work and completing larger projects); (2) frequently apply active learning strategies; (3) interact with each other about their work; (4) problem solve through project-based activities, which usually involve more critical thinking; and (5) regularly find information, make sense of it, and communicate it. Research provides evidence that students who engage in collaborative work, participating in more project-based learning, have higher levels of motivation (Wigfield et al., 1998; Guthrie and Wigfield, 2000). When students are motivated, they demonstrate improved achievement (White, 1989; Roth & Paris, 1991; Roderick & Engel, 2001; Haydel and Roeser, 2002; Gulek, 2003).”

The findings of Fuchs and Woessmann (2004) provide a good summary of research into the impact of e-learning on students. They published a statistical analysis of the relationship between technology and student achievement for the Program for International Student Assessment (PISA). The 2000 PISA was the first in a series of triennial international assessments of 15-year-olds conducted by the Organization for Economic Co-operation and Development (OECD). The assessment included problems in reading, math, and science, as well as questions about student background, school characteristics, and information on the use of computers and the Internet at home and at school. Fuchs and Woessmann analyzed data from 31 countries: 96,855 students tested in math and 174,227 students tested in reading. Their report concluded that: (1) the presence of technology is not, by itself, related to student achievement; and (2) the use of technology may help or hinder academic learning, depending on the nature of the use (Bielefeldt, 2000).

Thus, although technology is here to stay and is being rapidly infused into all aspects of education globally, the presence of technology must be coupled with a wider transformation effort to improve student outcomes. The integration of technology into an educational system is a complex process with implications for policy, curriculum, infrastructure, support and training (students, teachers, tech support staff, administrators, and others).

2. Impact of e-Learning Technologies on the Teacher and their Classroom Practice

In order to better understand how e-learning technologies in a classroom setting affects student learning, one must also examine how they might affect their teachers, their classroom practice, and their schools. This section briefly reviews the impacts that have been shown to occur when e-learning technologies are introduced.

Research by Haddad and Draxler (2002) conducted in the UK and Africa (Ghana, Rwanda, South Africa, Tanzania) identified two main reasons why teachers use ICT in the classroom. First, teachers felt that their own use of computers benefited their learners, and second, teachers felt learners benefited from using computers themselves. The learners were seen to gain confidence, self-esteem and renewed motivation. The authors categorize technology use in the classroom at five levels: presentation, demonstration, drill and practice, interaction and collaboration. They noted that when the pedagogy shifted from a teacher - centered classroom environment to a more learner - centered environment, the effectiveness of ICT was enhanced.

Similarly, Harrison, Thijus et al. (2001) explain that technology use creates a learner-centered environment by:

- Motivating learners by combining text, sound, color, and moving images that enhance content for easier learning
- Facilitating acquisition of basic skills through drill and practice
- Enhancing teacher training by improving access to and the quality of teacher training.

The use of ICT by teachers has brought about significant changes in classroom practice. Kozma (2003, 2004) reports that this was evident from a series of case studies conducted in 27 countries in Europe, Asia, North America, South America, and Africa. These studies show that innovative classroom use of computers depends on administrative support, teacher training, and supportive plans and policies.

There are thus significant challenges to the effective use of technology in a classroom. A 2006 study in South Africa noted the following change management obstacles experienced by teachers (Howie, Muller, & Patterson, 2005):

- Perceived school related obstacles
 - ICT is not considered useful in my school
 - My school does not have the required ICT-infrastructure
 - My school lacks digital learning resources
 - I do not have the flexibility to make my own decisions when planning lessons with ICT
 - I do not have access to ICT outside of the school.
- Teacher related obstacles
 - Lack of ICT-related skills
 - Lack of ICT-related pedagogical skills
 - Insufficient confidence to try new approaches alone
 - Lack of time to develop and implement ICT-using activities
 - Unable to identify which ICT tools will be useful.
- Student related obstacles
 - Students do not possess the required ICT-skills
 - Students do not have access to the required ICT-related tools outside of the school premises.

It is useful to recognize the need for an effective change transformation program coupled with e-learning implementation to address perceived barriers to ICT use.

It follows that many impacts on the teacher are related to change management. Professional development alone is not sufficient to effect change in any significant way. Teachers often face challenges when beginning to use e-learning such as the lack of support by administrators, technical support problems, technology breakdowns, and a lack of the necessary technological tools. When the culture within a school does not support e-learning, the culture usually wins out (Fullan, 1999). However, when there is a collaborative and supportive work culture the opportunities to make a difference in both teacher and student learning are high. A supportive work culture for teachers can be enhanced by the creation of learning communities (discussed below).

B. Economic Benefits of e-Learning

The potential economic benefits of e-learning can be classified into two categories: 1) e-learning improving general education, which in turn has economic benefits; and 2) e-learning creating a technology-immersed population with 21st century job skills, which in turn create economic returns for a country investing in e-learning. The previous sections have identified the first step in showing these benefits from e-learning, namely that these technologies will result in better educational outcomes. This section looks at the next step in the value chain, examining the long term economic reward of those educational investments. In particular, it will explore the mechanisms through which this will result in a higher quality and more productive workforce.

It must be noted that although e-learning can enhance economic outcomes through multiple mechanisms, it is difficult to measure the benefits. First, there is a significant time lag between the learning process and its effects on the student's employment or the society at large. Panel data following individual students over a long time frame is nearly impossible to find. The second difficulty is measuring the impact of the diversity of learning goals and outcomes. Workforce development is a one such goal, but other initiatives may focus on health, good citizenship, or the arts. Third, e-learning is only one component where technology and learning meet; e-learning as such is a relatively recent phenomenon yet a technological savvy workforce has been a foundation of many developed economies for several years. It is difficult to disentangle informal learning about and through technology from traditional and formal e-learning processes. A fourth confounding factor is the diversity in how ICT is used in schools. Technology can be used to deliver lectures, perform assessments, track progress, deliver educational games, etc. Not only do each of these methods have different costs and benefits, but each requires different efforts to integrate them into the pedagogical processes. The revision to the mode of teaching is often a larger challenge than the basic engineering challenges of installing new technologies. Finally, different geographies, income levels and histories will affect the benefits of the learning outcomes. In the United States, for example, a culture of computer gaming has generated substantial interest in educational games. Yet in developing countries, the widespread absence of TVs, computers and other electronic devices in the home and school mean that teachers and students need to learn the basics first.

In sum, e-learning is key component of the large challenge of educating the next generation of workers for a new, knowledge-centered economy. Once graduates are prepared for such jobs,

the positive effect of their education on the national economy will be apparent after the economy has generated employment opportunities for them. This is often the challenge in developing countries facing the chicken-and-egg situation of needing to create jobs while educating a workforce to fill those positions.

1. The Economic Benefits of Education

It is now canonically accepted in the economics literature that a more educated workforce will create greater economic output (Kozma, 2005; Sianesi & Reenen, 2005). The new focus is on the exact mechanisms for why this link occurs. In general, two approaches have been used to model this relationship. The first is to treat labor as just one of many inputs into an economic production function, and then study whether an educated worker creates more production than an uneducated worker. The second is a two stage process that initially examines the effect of an educated laborer innovating and making the production function more efficient, and then examines if production has increased as a result of these more innovative processes. These two approaches are articulated in greater detail below.

Historically the first approach described above was the most popular for modeling education and economics: classify the worker as yet another input into a production process. For example, a country's Gross Domestic Product (GDP) could be measured as a function of its total workforce, number of factories, available natural resources, etc. Then a researcher could study the benefits of education by examining whether an educated workforce, when plugged into this production function, results in greater GDP. Although it may be conceptually crass to model "human capital" just like any other form of capital, it does show positive results in the benefits of education. Krueger and Lindahl (2000) showed that the change in education positively affects economic growth, both in terms of an increase in GDP and an increase in income for workers. Many of the previous studies focus on developed countries only, given the higher quality and more accessible data, but some research has attempted to specifically address this question from the perspective of developing countries. Psacharopoulos and Patrinos (2002) examined data from 98 countries and they found that the average return to an additional year of schooling for an individual is 10%, and that people in the low-and middle- income countries benefited relatively more from an additional year of schooling than those in high income countries. As a general rule, the maximum marginal rate of return is found at the secondary school level, but the returns continue to accrue through college (Dedrick, Kraemer, & Shih, 2011). Based on these numbers, an e-learning tool implemented today in Tanzania that would incentivize and successfully guide students through secondary and college should create \$45,000 in economic value per student, measured at Purchasing Power Parity³.

The alternative model for examining human capital unpacks the role of human capital to better understand how education workers are more innovative and hence have a greater effect on output. For example, a well educated worker will presumably discover more efficient production means or create entirely new categories of production. Some studies such as that performed by Marvel and Lumpkin (2007) showed from a sample of 145 technology entrepreneurs that innovativeness is positively related to formal education. In contrast to the traditional method which merely treats human capital as a generic input that is transformed into output through the

³ Based on the average GDP per person measure at Purchase Power Parity, time an estimated 40 years of work, and a 10% increase in income per additional year of school.

industrial machine, this new approach attempts to model the uniquely human ability to transform the production process. Finding a link between education at this level and productivity, however, is more challenging. For example, Benhabib and Springel (1994) concluded that the effects of educational attainment are not related to economic growth using this form of economic modeling. This is likely due to the challenges of creating economic models to capture the full complexity of human activities in economic processes. A much broader range of issues dealing with creativity, collaboration methods, social norms, other economic infrastructure, and public policy initiatives make it difficult to link these fine grained human activities with aggregated economic outputs. Although economists generally accept that education improves economic output, existing studies have not yet been able to rigorously link specific educational activities to broader trends.

2. The Economic Benefits of a High Tech Workforce

Beyond the basic challenges of creating an educated workforce, it is important to align the educational outcomes with the demand for future jobs. In a globalized, knowledge-based economy, this requires a workforce that has a strong background in the sciences, engineering, and information technology. A large and growing body of research shows that such a high technology (high tech) workforce will create substantial economic benefits. For example, Lichtenberg (1995) reported that one Information Technology (IT) worker can be substituted for six non-IT workers.

When examining the linkage between technology and economics, the first question is why a high tech worker creates greater economic outcomes. In general, technology has been found to contribute to economic growth in three ways (Oyelaran-Oyeyinka and Lal 2005):

- 1) Technology creates new types of goods to be produced. This means that the actual act of producing technology goods and services is an increase in GDP, in much the same way that producing any good or service affects GDP. This requires greater employment generating greater economic output to satisfy the consumer and business demand for technology equipment. However, in this way, there is technically nothing special about technology compared to other types of production.
- 2) Technology goods and services are more efficient substitutes for other types of goods and services. A classic example is market discovery mechanisms using mobile technologies. If a Tanzanian herder can use the mobile phone to discover which regional marketplaces are offering the best prices, he would be saving the labor time of personally visiting several markets to gather information. Furthermore, since the herder may drive the cattle from market to market, the IT solution may reduce strain on the cattle. Hence, the technology becomes a substitute for the labor intensive processes, making the system more efficient and freeing the herder to focus on more economically efficient activities.
- 3) Technology is a special capital input, producing economic spillovers (UNCTAD, 2007). Information technology in particular exhibits properties of non-excludability, where knowledge learned by one individual or firm can create benefits for non-participating third parties. For example, the herder described above in Item #2 could tell a fellow herder about the economic benefits of using mobile phones to find the best prices for cattle. The herder is essentially no worse off from teaching other herders about this technology, but the other herders become better off. In fact, these knowledge spillovers

have been identified as the primary driver of economic growth in Paul Romer's Nobel Prize winning research (Romer, 1986).

In sum, a knowledge-based economy is a growing economy. Technology investment results in greater GDP. Greater GDP results in more technology investment. This results in a virtuous feedback loop. This result tends to hold for a variety of different definitions of ICT, including traditional land-line telecommunication, mobile phone investments, and broadband Internet access.

The above framework describes why we would theoretically expect growth from an economy built upon technology workers. The next logical question is whether the empirical evidence finds any corresponding benefits. Because of issues of availability and data quality at the sub-national level in developing countries, most of this research has focused on the country level and how technology affects overall economic output. Usually, this productivity is broken down into two factors: ICT capital and ICT labor. The capital portion represents the productivity improvement attributable to investments in computer hardware and software. Although this is not directly attributable to jobs and human resources, these capital resources require trained technology workers to maintain. The more direct factor is the benefits of ICT labor, which represents technology trained individuals and the benefits they bring to the economy. Dewan and Kraemer (2000) show that productivity increases by approximately 17% as a result of ICT investment. Developed countries average an increase of 14%, though that result was not statistically significant, indicating a large amount of variability in the actual returns from investment, depending on the country.

ICTs in education can reduce the costs of education per student by increasing the relative economic benefit of investment in education. ICTs can have differential economic benefits by improving how instructional methods are delivered. ICTs can deliver instruction in a more efficient, less expensive, or more accessible way (Clark, 1983). For example, e-readers can allow African children to access thousands of books at relatively cheap price once the reader has been purchased. In addition to direct economic benefits, some believe ICT can even enhance the quality of education by supporting student understanding as well as helping them to develop skills needed to create knowledge (Kozma, 2005) although some scholars such as Clark (1994) believe that ICTs never directly influence learning itself.

Beyond the broad benefits to economic output, technology investment can also create benefits for the worker through higher wages and more prestigious employment. Most of the studies in this area focus specifically on the benefits of knowing about ICTs: "By learning ICT skills, students become better prepared for work that increasingly involves the use of ICT" (Kozma, 2005, p.142). ICT workers can be examined in several ways (Romani, 2009). For example, the OECD (2005) compared ICT specialists, advanced users, and basic users. ICTs constitutes the main part of their job for the ICT specialists who can develop, operate and maintain ICT systems, while ICTs are a tool for both advanced users who can use advanced and often sector-specific software tools and basic users who can use generic tools such as Word, Excel and PowerPoint.

As ICTs become a vital element in the working lives of people and for the competitiveness of enterprises in many countries, the smooth supply of ICT workers in the labor market becomes

important for the industrial efficiency and economic gains. A mismatch of supply and demand of IT workers is a global issue (Bailey & Stefaniek, 2002). Frinking, Ligtvoet, Lundin, and Oortwijn (2005) analyzed the current situation relating to the supply and demand of ICT practitioner skills in the European Union and its member states and concluded that there is no indication of a general practitioner skills shortage at the EU level. However, the decline of supply of highly-skilled ICT practitioners and persistence of digital illiteracy still raises concerns for EU policy makers (Commission of the European Communities, 2007). They call for additional attention to be paid to ICT workforce development for the future.

In both developed and developing countries, ICTs affect employment and wages for the evolution of the composition of the labor force: the unskilled workers are the main losers in sectors where investment in technology and greater productivity are high (UNCTAD, 2007). Computer-based networks are changing how people work and are paid. The rewards for multi-tasking are increasing and employers seem to prefer employees with broad-based education and conceptual and problem-solving skills. Skills can also be acquired on the job through on site-training. The returns to higher learning are increasingly being recognized.

At the individual level, the effects of ICT skills may vary in different social contexts because what are considered advanced ICT skills vary depending on the local context. Walton, Putnam, Johnson, and Kolko (2009) examined the relationship between ICT skills and employability in the context of a transitioning economy by examining the Kazakhstan case. According to them, “skills that are considered as basic computer literacy in the developed world are, in many developing and transitioning countries, considered sophisticated skill sets held by small segments of population” (p.1). Especially when ICT skills in those countries are combined with other factors such as higher education, these skill sets are found to be associated with prestige jobs.

Although the benefits of a high tech workforce are great, it must be acknowledged that a more productive workforce also may result in a short term loss of some jobs. This Schumpeterian creative destruction is a fundamental element of the long term restructuring of the economy to achieve greater total economic benefits. If all Tanzanian cattle herders were to continue their work as cattle herders, it would not be possible to transform the workforce to meet the needs of a modern economy. Instead, some cattle herders will discover how to use technology to more efficiently manage larger herds, reducing the total number of potential herder jobs, but freeing up a larger portion of the total labor force to pursue 21st century jobs in science and engineering. The short-term cost of this economic transition will be offset by the long-term benefits in the economic transition.

3. Assessment of the Benefits of e-Learning

The literature referenced above also provides some guidance on how to properly assess the benefits of an e-learning initiative and the economic outputs. One of the great challenges of performing any economic impact, especially with technology interventions, is dealing with the time lag between interventions and outcomes. To take a related example, assessment of Information Technology for businesses in the mid-1990 was plagued by the productivity paradox, where economists could not find any economic benefits from computer investments in spite of their great potential. As Nobel Prize-winning economist Robert Solow quipped, “We see

computers everywhere except in the productivity statistics” (Solow, 1987). e-Learning interventions could run afoul of the same issues.

The solution to the productivity paradox was a simple improvement in the assessment methodology. As Brynjolfsson and Hitt (1996) discovered in their ground breaking research in 1996, the problem was with time lags. It was unreasonable to expect that a technology investment would instantly yield an increase in business productivity. Instead, it takes time for firms to integrate the technology into their business processes. By integrating time lags, these two researchers were able to find productivity improvements from technology investments approximately two years after the initial investment. This finding was replicated in broader contexts as well. A one or two year lag following investment in ICTs has been found in several studies (e.g., Kelly & Petrazzini, 1997; Hargittai, 1999; Oyelaran-Oyeyinka & Lal, 2005).

This reflects the need to adapt educational and economic processes to take advantage of the new tech-savvy population. For example, it should not be surprising that simply handing a computer to a person will suddenly cause them to be more productive. In fact, the process of teaching individuals how to effectively use the technology can result in a short term diversion of resources, resulting in a short-term decrease in the productive use of the technology.

Likewise, in the e-learning environment, it is important not to fall into the trap of expecting immediate returns from the intervention. For example, a secondary student that participates in an e-learning program to enhance her knowledge of physics will not contemporaneously cause jobs to be created. However, this improved physics education will hopefully inspire her to complete her secondary education, pursue a college degree in engineering, and eventually become a well-paid member of the 21st Century workforce and an active citizen interested in good governance and an efficiently operating economy. This time lag means that an effective assessment program either needs to focus on more immediate metrics—e.g., an intent to pursue a college degree and become an engineer—or to recognize that any assessment must include a long term panel to follow student through the extended transformative process between intervention and economic outcomes.

C. Societal Impacts of e-Learning

The impact of access to education on different members of society can be significant. Beyond the improved skills, income and employment effects on graduates as described above, other impacts of education include improved health and wellbeing, particularly among girls and women. This section on societal impacts briefly considers these types of impacts of education generally on society in developing countries, and then considers more closely the relationship between e-learning and society—particularly how the societal context can affect the ability of e-learning programs to provide their potential benefits among all students. Societal aspects such as being in a rural location, a female student or speaking a different language can all affect access to and use of e-learning programs, and their success.

One of the most well documented impacts of education on society is that of improved health. Indeed, because of this, one of targets of Millennium Development Goal Five regarding improving maternal health is to promote girls going school, especially primary school. As stated in the Goal (UNICEF 2011),

“Educating girls for six years or more drastically and consistently improves their prenatal care, postnatal care and childbirth survival rates. Educating mothers also greatly cuts the death rate of children under five. Educated girls have higher self-esteem, are more likely to avoid HIV infection, violence and exploitation, and to spread good health and sanitation practices to their families and throughout their communities. And an educated mother is more likely to send her children to school.”

Both primary and secondary education has also been shown to be key components of an effective program to prevent HIV/AIDS transmission. Educated women are more likely to know how to prevent HIV infection, to delay sexual activity and to take measures to protect themselves. Education also makes young men more receptive to prevention messages. In many developing countries, the more educated and skilled young people are, the more likely they are to protect themselves and the less likely they are to engage in risky sexual behavior. The benefits of education come from actual knowledge that students gain about HIV, from training in negotiation and life skills and from their increased ability to think critically and analyze situations before acting. Women with post-primary education are five times more likely than illiterate women to know facts about HIV/AIDS (UNAIDS, UNFPA & UNIFEM, 2005; Vandermoortele & Delamonica, 2000).

Additional impacts that particularly post-primary education has been shown to have include reducing poverty, delaying marriage of girls, and increasing decision making power. Secondary education plays a crucial role in preparing for a life-long learning perspective. These are all important reasons why governments in Africa have recently been heavily investing in universal primary school education and in expanded secondary school education.

The education provided by these secondary schools however, may not be accessible to all segments of society or all regions of a country. Access to e-learning has been found to reflect this access to education and to ICT generally in the wider society. Research has shown that a gap in access to ICT exists between countries, and an even larger gap exists within countries between urban and rural areas, between men and women, and between rich and poor. This has been termed the digital divide, defined as *“the gap between those with regular, effective access to digital technologies, in particular the Internet, and those without.”*

Access to secondary school education within countries follows a similar pattern. Figure 4 in Annex 3, for example, illustrates student attendance in Tanzanian secondary schools. The statistics reflect large differences in access to education between urban and rural schools, rich and poor areas, and male and female students. Thus physical access as well as socioeconomic factors, such as age, wealth, health status, physical mobility and cultural practices, are often barriers to access and use of e-learning (Naseem, 2010; Sutherland-Addy, 2008).

Expanding e-learning in developing countries may lead to two opposing outcomes—it can either widen these existing inequalities in access to ICT and education, or it can reduce inequalities by providing information and educational opportunities that would otherwise not be available. Ensuring the second outcome requires understanding the current distribution of access

to education, ICT and other technologies, and the reasons for the inequitable distribution. This section describes some of the current patterns and implications for impacts on e-learning.

1. The Rural-Urban Divide

The global digital divide is a term used to describe the gap between well connected and poorly connected nations, while at the national level, there is often a strong urban-rural divide. In developing countries, most Internet users gain access through public access points like Internet cafes. The divide is thus closely related to geographic proximity of venues with technology to access the Internet.

A statistical analysis analyzing the factors behind digital inequality within and between African countries found that differences of access and use could be explained by five factors: 1) differences in the technical devices that people use to access the Internet, 2) location of access, 3) the extent of one's social support network, 4) the type of activities the device is used for, and 5) one's level of skill (Oyelaran-Oyeyinka and Lal 2005). It concluded that although infrastructure is a critical factor, the social context, education and technical knowledge of the individual user are also key. The study also found a strong correlation between Internet access and national economic development, although the causal link (whether the Internet led to development or vice versa) was not clear.

These conclusions are mirrored in a study conducted in Tanzania. Furuholt and Kristiansen (2007) found that Internet users and usage at different sites are surprisingly uniform. Most users, particularly in rural areas, are young people, especially students. Also, most users are well educated (one-third actually have university education).

The use of mobile phones illustrates possible future trends of ICT technologies in urban and rural areas. Mobile penetration in African urban centers is near the average penetration of all developing countries, whereas access in African rural areas has lagged because of difficulties caused by the lack of distribution channels, education and poverty (Anderson 2006). However, the growth rate of teledensity penetration in Africa has become the fastest in the world as the cost of handsets, calls and connection charges have declined, and as teledensity coverage has grown. Indeed, the mobile cellular growth rate has started to decline in developing countries as the market becomes more satisfied. The growth rate declined from around 32% annual growth in 2005/06 to 18% in 2009/10. The mobile penetration rate in Africa was 41% at the end of 2010 (compared to 76% globally) reflecting continued potential for growth, but also continued digital divide between Africa and other parts of the world, and between rural and urban areas of Africa (ITU 2009).

In contrast to mobile telephones, Internet penetration, particularly in rural Africa, is growing more slowly (Annex 1). The percentage of people using the Internet in Africa, for example, is currently only 10.8% compared to a global average of 27.9%. Africa has by far the lowest penetration rate of broadband Internet of anywhere, with a penetration rate of less than 1% (ITU 2009). The low levels of access are in a large degree due to cost. Although prices are declining as undersea's cables reach coastal cities in Africa, the cost of Internet is much higher in Africa than elsewhere. Ethernet cables currently serve only urban centers across much of Africa. Rural areas and smaller urban centers in Africa can access Internet only through satellite systems or through

cellular networks. The satellite systems often require expensive installation and high monthly fees, whereas the cellular networks require little installation costs. Their data transfer speeds can be slow (insufficient for sharing large amounts of data or conducting video conferencing, for example) and are relatively expensive per byte. The result is that most rural areas have little access to the Internet, and that providing Internet to rural schools can be a continuing, expensive cost. Different solutions include using a Local Area Network (LAN) type approach to share Internet among schools, or providing ample software and content on resident servers in schools to be shared among users using wireless or wired communications.

Another technical challenge that has prevented e-learning from being offered in rural areas has been the lack of reliable electrical power. In Africa and many other developing areas, the electrical grid does not yet reach more isolated rural areas, and the grid itself does not provide a steady or reliable source of power. Many governments do not have sufficient funding to pay electrical bills for all schools, either. Meanwhile, e-learning technologies, whether small hand-held devices or projectors, require electrical power. In these situations, it is critical to design an efficient, low-power e-learning system. Different solutions to provide power off the grid include solar panels, diesel generators, and geo-thermal and wind energy. Solar is often used. Commercial and specially designed systems are now available for recharging small batteries to large systems that power a computer lab or an entire school. Initial costs for solar can be high, though they are declining. Like the Internet, providing electrical power to underserved areas can require a significant initial investment and some continuing costs.

Despite these challenges, e-learning technologies have the potential to significantly improve access particularly to science and math education for rural or otherwise disadvantaged schools. These schools often are not able to attract or retain science and math teachers because the schools are in undesirable, isolated rural locations. e-Learning would provide these teachers and students otherwise unavailable access to ICT knowledge and skills, as well as improved educational content. Currently, however, most e-learning opportunities tend to be in urban areas due to the infrastructural and other challenges of rural areas.

2. Culture and Language

e-Learning has the potential to play a transformative role in a society. Culture, however, can play an important mediating role affecting how technology and e-learning approaches are adopted and adapted, and how successful they are in actually improving learning. The potential transformative role of e-learning often runs against educators' preferences for teaching in familiar ways that do not affect life in classrooms. Educators tend to use e-learning approaches in culturally familiar ways that may reduce their effectiveness.

Educators from different societies are incorporating and using e-learning technologies in different pedagogical cultures. Although the cultural differences can be subtle, understanding them can help explain the constraints and alternatives for e-learning. Zhang (2007, 2010) conducted analyses comparing Eastern, especially Chinese, and Western pedagogical cultures and how they affected their e-learning preferences. His findings are summarized below. Although there are major differences between Eastern cultures and African cultures, there are several similarities in their educational systems and teaching styles. Adapting e-learning for an African pedagogical culture may lead to similar experiences to those in Eastern countries.

Zhang's work provides insights into what cultural factors affect e-learning approaches, and what to consider in designing e-learning programs.

He found that Western learning culture tends to be more learner-centered, activity-focused, and individualized. Western students and educators tend to attach importance to questioning and criticizing information presented by an instructor. Technology is more likely to be content-open and used as a productivity tool (e.g. word processing, simulations, Internet research, graphics and spreadsheets).

Easterners tend to favor collectivism. This cultural tradition, together with social factors such as centralized political systems and rapidly growing populations, have shaped a group-based, teacher-dominated, and centrally organized pedagogical culture:

Culture of Examination:

- Education is regarded as an essential way to compete for higher social statuses;
- The performances of learners, teachers, and schools are largely defined according to exam scores;
- Preparation for high-stake exams poses tremendous pressures to learners, parents, teachers, and administrators.

Centralized Educational System:

- Central governments design and execute policies and standards for school finance, curriculum, textbooks, assessment, and teacher preparation;
- Teachers are required to teach uniform content, often based on the standard pace in reference to official teachers' guides.

Eastern schools have historically emphasized knowledge acquisition over more process, activity based learning. Chinese students treat texts and the instructor as highly authoritative sources of knowledge, and expect the instructor to provide structure and guidance. This has resulted in a focus on learning of content and strong accountability. However, it may lead to weakness in self-directed learning abilities, creativity, and critical thinking skills. Facing the challenges of a knowledge society and globalization, most Eastern nations are now attempting to steer their use of e-learning to promote students' problem solving capabilities, lifelong learning skills, and creativity and inventiveness.

A typical image of an Eastern classroom involves a teacher conducting expository teaching in front of a large class of well-disciplined students, seated in rows. Good teachers model responsible learning behaviors, stimulate thinking by asking thought-provoking questions, and design assignments to promote understanding and integration of knowledge. *Expository teaching* is thus the most frequently used method, particularly where the primary objective in the curriculum is the mastery of standardized facts, concepts and procedures.

Computers are being used to support such expository teaching especially in large classes. Educators often have a shortage of learning and teaching resources, and use ICT as a new information delivery tool that presents information in vivid, attractive ways. They would also like it to deliver drill and practice with immediate feedback. This expectation leads to a tendency towards software that can aid their expository teaching. Teachers prefer content-bound and

curriculum-compliant courseware and resources, including tutorials, drills-and-practices, computer-assisted tests, and Web gateways that sort learning resources in line with the national curriculum. There is a strong need of digital projectors or LCD display boards to help deliver lectures in large classes without requiring significant changes in the teacher's role.

Language, too, can affect the design of e-learning programs and their success, particularly when the software, learning materials and Internet is in a language in which students and teachers are not strong. In Tanzania, for example, students switch from learning in Kiswahili in primary school to English as the language of instruction in secondary school. The national language and common lingua franca is Kiswahili, and most radio and television programs broadcast in Kiswahili. The students usually have had some English language classes in primary school, but many are not well prepared to enter into an English-only mode. Meanwhile the dominant language on the Internet is English, and most software and learning content is in English. Students and teachers with limited English may be marginalized (Naseem 2010). e-Learning can thus require first becoming proficient in reading a second (or third) language before its potential can be met. However, e-learning and the Internet can also be a strong motivator for students to learn English.

3. Gender and e-Learning

ICT can be a strong change agent. In uprisings and pockets of challenge throughout the world we have seen the impact of ICT and social media to coordinate and communicate political and social movements. Access to ICT can empower social and economic development, as well as provide employment and grow the economy. But where are females in the mix? There is currently a digital divide between groups in society, and women in developing countries are often “within the deepest part of the divide” (Hafkin & Taggart, 2001). There is already evidence that gender inequities are being replicated in schools with girls using computers and the Internet less than boys (Olatokun 2008).

Girls and women in developing countries thus need to be specifically written into ICT initiatives, particularly in schools, or their participation in education, the economy and the political debate may decline further relative to boys and men. UNICEF (2011) estimates the number of out-of-school children globally at 93 million – with the majority being girls. Almost 80 per cent of the out-of-school children live in sub-Saharan Africa and South Asia. School attendance is rising rapidly as governments institute new education-for-all initiatives, but attendance in secondary schools is still low. Only 60 per cent of children of the appropriate age attend secondary school worldwide. In sub-Saharan Africa, that number drops to only a quarter. One unexpected side effect of the increase in children attending school is that the percentage of girls in secondary school in Africa actually dropped—studies showed that there was greater disparity in favor of boys in 2005 than in 1999 (UNESCO, 2008). Many factors contribute to the girls' inferior educational opportunities and experiences. In secondary education, issues such as the lack of a safe learning environment, gender-based violence, poor sanitation facilities, the burden of caring for younger siblings or sick family members, early pregnancies, family pressure to get married, and the need to pay school fees acutely constrain girls' ability to remain in school (Ugwuibe, 2009). Governments, international organizations and donors often have programs to improve girl's access to education, with marked success in some countries.

e-Learning technologies could potentially play an important role in reducing the gap in access to education by girls in developing countries. Currently, however, the gender gap in access to education is mirrored in a gender gap of access to and using the Internet and other ICT technologies in the wider society. Fewer girls or women in developing countries have mobile phones, for example, or visit Internet cafes (Mercer, 2005). This report's authors and others have witnessed computer labs in schools being used far more by male students than female students, possibly because of the cultural expectation that girls not push themselves forward (Olatokun 2008). Few gender-disaggregated statistics exist, however, on ICT access and use in developing countries. One Africa country that has conducted such a survey, Senegal, found that 11% of men but only 5% of women were Internet users (ITU 2011a). There is even less documentation of the impact of e-learning on girls as compared to boys. Nevertheless, gender in secondary schools in developing countries is a large topic of research because of the gap in the access of girls to education.

Much has been written about the importance of encouraging gender inclusiveness of educational technology (Heemskerk, ten Dam, Volman, &Admiraal, 2005). Topics examined include how boys and girls learn differently with technology, whether technologies or software favor one gender over another, and how to encourage teachers to address gender differences when using technology in the classroom.

What makes educational technology suitable and attractive to females? From a landmark study by the American Association of University Women, and from ours and other's research (Heeter et al., 2009), it has been found that girls have definite preferences for how they chose to learn with and about technology. For instance, girls prefer collaborative community ways of learning how to use technology, they like to have order and instructions to guide them, they prefer to learn about a subject of interest and then learn to use the technology as a tool rather than it being the focus of study, and finally they prefer to learn from female role models.

In concert with the pedagogy, the tools themselves need to be designed to be non-sexist in their assumptions and representations. Questions to ask, for example, include, "Do the illustrations and graphics of the program represent male and female persons, and are they represented in a non-stereotypical way? Do audio narrations include male and female voices and a variety of music and sounds that will appeal to both sexes?" (Heemskerk et al., 2011). Representations such as these will signal early in the process whether or not the technology tool was designed with female participants in mind.

According to Sanders (2005) who wrote "Lessons Learned in 22 Years of Working with Teachers about Girls in IT", approaches that are successful in teacher training workshops regarding the sensitive subject of gender bias in education include,

- 1) Diffuse resentment of teachers (who may think you blame them for the gender gap). Explain and emphasize the universality of gender bias, and that it is often inadvertent.
- 2) Use local data when possible
- 3) Stress the importance of teachers finding out about gender bias themselves (rather than take the presenters word on it) through mini-assignments such as observing eye contact of teachers with girls and boys.

- 4) Repeated training sessions are better than a one-time approach. Follow up is essential. Development happens over time.
- 5) Reward teachers who do gender work. Rewards could include access to and training with technology, continuing education credit, drawing for a gift certificate, etc.
- 6) Be explicit. Have the teachers tell the class what they are changing to ensure gender-fair teaching.

e-Learning is thus being introduced into educational systems in which girl students are often participating less than boy students. Access to and use of ICT technologies in the wider society is also gender-imbalanced in many developing countries. Nevertheless, introducing e-learning technologies into schools has the potential to assist girl students to improve their ability to participate and thrive in schools, and their new knowledge of computer technologies will certainly place them in a stronger position in their adult lives.

IV. Best Practices

The topics discussed above provide rich detail about what impacts e-learning can have, and what factors can affect the success of e-learning programs. The next section takes that one step further to describe specific programs that integrated e-learning into schools and educational systems in developing countries, and what lessons can be drawn from them. This is followed by a summary of these lessons—the key components of successful e-learning programs.

A. Case studies

1. Algeria

Michigan State University working with Creative Associates, International, USAID, and the Middle East Partnership Initiative (MEPI) developed and implemented a three-year program to address the issues of infusing technology into the Algerian secondary education system. Through this initiative the team created a demonstration project connecting 28 secondary schools in northern Algeria with counterpart schools in the United States. The project activities included a long term ICT integration and e-learning plan in which both teachers and students would benefit from the use of e-learning and ICT.

The lessons learned from this project are many but, most importantly; **we learned that the teacher is the key to success in e-learning.** Teachers participating in our program were often directed to participate by the Ministry of National Education even if they lacked the requisite skills. In those cases the responsibility for learning how to use the technology was left up to the teacher. Although program members did not consider this the best practice, it worked. At times, teachers relied on their students for support.

We also learned that the teachers in the program often attracted other teachers who had initially resisted using technology. The peer-to-peer interaction yielded very positive results. Through this interaction, teachers created a wider learning community and participation that spread beyond the initial program. The evidence of this outcome was demonstrated by the fact that, initially only four secondary schools were participants but by the end of the second year, an additional 24 schools joined the program. The program thus became sustainable beyond the short term of the funding.

The objectives listed below were essentially accomplished. Unfortunately, the project impacts were not measured, nor were they intended to be, at the conclusion of the project. The objectives for this program were as follows:

Educational Objectives:

- Upgrade the level of knowledge and skill set of Algerian Students
- Provide an environment where the students can apply their knowledge and skills to real life problems and situations.
- Provide a facilitating environment through which students can build on their acquired knowledge to build on existing concepts, or build new concepts altogether.
- Empower students with the tools necessary to enter the 21st Century workplace and remain self-sustaining citizens (including skills such as adapting to change, learning how to learn, communication skills, team-work skills, etc.)
- Provide students with an interactive, collaborative learning environment through which they can interact with their community as well as interact with, and understand, the larger world. The purpose is to empower to generations of global citizens who are deeply rooted in their culture and heritage as well as open and understanding of the global needs, trends, and lifestyles.
- Upgrade the level of knowledge and skills of the teachers in parallel to that of the students. Empower the teachers to facilitate the learning process by transforming themselves into team leaders and role models of “continuous learning”.

Social Objectives:

- Provide Algerians with the tools through which they benefit from and capitalize on life-long learning opportunities. Life-long learning opportunities within this context include the following:
 - Access to learning content across Algeria and providing access to all educational content to every individual interested in learning or re-learning a skill.
 - Providing professional development and life-skills content to the larger Algerian community.
- Help disseminate ICT further into the society by providing ICT tools that are equally available to males and females, rich and poor, urban and rural citizens.

Economic Objectives:

- Include local ICT professionals in the development and implementation to upgrade their “transferable” knowledge and expertise.
- Transfer knowledge and expertise in learning technologies, design approaches, project management, best practices, and indicators/assessments to the Algerian partner institutions.

Lessons learned from this project that are applicable to other developing countries include:

- 1) Focus on the classroom teacher
- 2) Establish methods and tools that enable teachers to create their own “communities of practice”
- 3) Encourage teachers to engage their students with support and innovation

- 4) Challenge teachers to incorporate technology and e-learning into one aspect of their teaching and curriculum
- 5) Provide teachers with professional development that focuses on how to use technology and how technology and e-learning can change their practice of teaching in positive ways.
- 6) Encourage and reward teachers for using new and innovative ways of teaching and e-learning.

2. Lebanon

Michigan State University participated in a three-year USAID/MEPI funded program with the Lebanese American University in Lebanon, which was designed to train Lebanon's in-service teachers on both how to use and how to teach with technology. A new teacher education program was developed and piloted with approximately 30 secondary school teachers.

The overall goals of this program and of this university education partnership included:

- Fostering critical thinking and inquiry learning through a comprehensive curriculum, and providing teachers with pedagogical skills that enable them to foster critical thinking and inquiry in their classrooms;
- Developing an ICT in education curriculum that meets the specific needs of Lebanese teachers and is relevant to the nation's needs;
- Providing teacher professional development (both in-service and pre-service) that results in innovative teaching practices designed to motivate students at the primary, secondary, and postsecondary levels.
- Developing administrator professional development programs that support the use of ICT in education and support innovative teaching and learning practices at all levels.
- Developing and delivering a model ICT teacher professional development program that focused on the innovative uses of technology for teaching and learning, and
- Developing better teachers, whether or not they use technology.

Over the three-year life of the project, ICT standards for teachers emerged. These standards were adapted from a program offered to Michigan's in-service teachers and created by the MSU College of Education. The standards, which were accomplished in this project to varying degrees, state that teachers completing this program, will:

- Design, develop, and implement student-learning activities that integrate ICT for diverse student populations (emphasis on females);
- Identify and apply resources for staying current in applications of ICT in education;
- Demonstrate knowledge of uses of multi-media, hyper-media, telecommunications, and distance learning to support teaching/learning;
- Demonstrate knowledge about instructional management resources that assist in such activities as writing and updating curriculum; creating lesson plans and tests; and promoting, reinforcing, and organizing data regarding student performance;
- Use information technologies to support problem solving, data collection, information management, communications, presentations, and decision-making including word processing, database management, spreadsheets, and graphic utilities;
- Demonstrate knowledge of equitable, ethical, gender, legal, social, physical, and psychological issues concerning use of information technology; and

- Use ICT to enhance continuing professional development as an educator.

3. Pakistan

From 2008 to 2010, Michigan State University directed the higher education component of the USAID funded PreSTEP (Pre-Service Teacher Education Program). The primary purpose of this program was to assist the Government of Pakistan, the Higher Education Commission and the Ministry of Education in achieving its goal of improving educational quality in Pakistan at all levels. The Michigan State University College of Education component of Pre-STEP focused on pre-service teacher education: on upgrading skills of teacher educators, on rationalizing and standardizing the curricula used for pre-service teacher education, on upgrading the infrastructure in the participating academic institutions, on strengthening educational research output, and in generating policy that strengthens teacher education at all levels. Michigan State University worked intensively with 15 pilot universities to improve the quality of pre-service education and in turn the quality of education throughout.

Michigan State University's approach was to provide support and consistent momentum to a large-scale change process. From the beginning the strategy was to support change from within the system while introducing best practices from the U. S. and elsewhere. "Early adopters" of technology change were identified and invited into the project. Program managers considered but did not focus on the resisters but rather put energy and resources toward those who were already moving towards the needed change.

To facilitate change, the program began with a summit on "Leading for Change" and a process map was developed that established a path. By starting with a shared understanding of change and continuing to reinforce that process throughout, the project was able to maintain clarity in the large-scale work that was to be done. Pakistani educators were the leaders of this project and the MSU team provided them with professional development and attentive support to be successful.

The list of best practices that emerged from this project included:

- 1) Engage "early adopters" with interest already in technology and online learning. Reward them with support for their thirst for learning (a necessary trait of early adopters) and tools for taking their interest the next step. Let them be a shining example to others. Leadership should come from the key stakeholders. Sometimes these may be official leaders and sometimes leaders that emerge from within the system because of their expertise and/or passion for the change.
- 2) Provide a map of the change process---the principles of change – and create a shared understanding of the change process. Let this guide the development of a detailed work plan that can be flexible as needed for taking advantage of surprises and new benefits that reveal as well as letting go of tasks that are not going anywhere.
- 3) Learning must be ongoing, exciting, and easily accessible to those engaged in the project. Furthermore, the learning needs to be authentic, built around the real work of the project so that project advancement is the lead and the learning supports the quality of the outcome as well as its capacity to continue beyond the time when funding of the project is completed.

4. Chile

An example of a broad, national ICT program that has met with success is the Enlaces initiative in Chile. Enlaces began in 1992 as part of the Chilean government's educational reform program. As of the year 2000 the Enlaces initiative led to ICT implementation in over 5,000 public schools, which includes 100% of secondary schools (Hinostroza, Hepp, & Laval, 2005). However, the goal of Enlaces goes beyond ICT implementation to the total transformation of school culture through integration of ICT in teaching and learning practices (Hinostroza et al.).

A number of key strategies have contributed to the success of this Chilean program. First, teacher training is considered a focal point of the initiative and has included initial training for two years and follow-up training for at least another year, as well as offering "Educational Information Technology Encounters (Hinostroza et al., 2005, p. 4)" where teachers and students from different schools can meet, exchange ideas, and observe practices from other schools. A second key strategy involves building a national infrastructure support system, which involves a number of universities in providing training programs and activities (Hinostroza et al.). A third strategy is providing technology that is easy for initial users to learn, called La Plaza. Fourth, the private sector is involved in providing support, including equipment and internet expansion (Hinostroza et al.).

Evaluations of Enlaces within Chile and by outside organizations such as UNESCO and the World Bank show positive results for students, teachers, and communities. For students, benefits include growth in knowledge, reading comprehension, social interaction, self-esteem, and motivation (Hinostroza et al., 2005). From teachers' perspectives, positive outcomes include improved school climate, more opportunities for professional development, and positive impacts on the teaching-learning process (Hinostroza et al.). Impacts on the community are also evident, including increased school prestige and parental support (Hinostroza et al.). The Enlaces example stands out as positive example of reform at the national level.

5. Malaysia

Another nation that has put a major spotlight on e-learning in schools is Malaysia. As part of the government's Vision 2020, a number of ICT initiatives have been implemented, including the Malaysian Smart School, begun in 1997. The goal of the project is to develop students who are self-motivated, lifelong learners and was expected to be available in all Malaysian schools by 2010 (Digital Learning Newsletter, 2008). As in the Chilean case, Malaysian officials have recognized the importance of teacher professional development as a key factor in the sustainability of e-learning. A meta analysis of research conducted in Malaysia showed that with proper training and support, even older teachers were able to successfully integrate e-learning into their teaching practices (Lau & Sim, 2008).

6. South Africa

A comprehensive study of ICT in education was conducted by the International Association for the Evaluation of Educational Achievement (IEA) and reported on in the Second Information Technology in Education Study (Howie, Muller & Paterson, 2005). This study looked at the status of ICT in education in 26 countries including South Africa.

In brief, the study examined the ICT and e-learning integration process in the 26 countries; national policy, infrastructure, curriculum and pedagogy, staff and teacher development, school policies and usage of ICT, and successful practices (Howie, Muller & Paterson, 2005). Most countries have policies for strengthening the role of ICT in education. They recognize that “knowledge and competencies needed in the workplace and in society will be increasingly short lived due to the fast pace of development and increasing information accessibility, which implies an urgent need for lifelong learning skills as a new type of educational aim for our schools.” (Howie, Muller & Paterson, 2005). However, in South Africa the concern is that many schools have policies for ICT integration and e-learning but few have implemented them.

While this study reports on many factors and indicators for ICT and for e-learning, the key takeaway for African countries is the importance of the teacher. The report noted that, according to school principals, most teachers’ lack of ICT knowledge and this was a major obstacle in realizing the schools’ ICT goals. Most schools had a policy that teachers must receive training, and as a result some teachers attended basic ICT courses. However, the financial constraints of teacher training resulted in a low number of actual participants.

There were several other key observations regarding the teachers. The first is that when teachers were faced with mandates on the use of technology, they tended to use the technology for personal productivity rather than learning. The technology assisted with attendance, word processing, and assessment. But as a pedagogical tool it failed to realize its potential. The second observation was that teachers often resisted the use of technology and e-learning because of an insufficient amount of time needed to prepare any lessons and especially to rework the lessons to incorporate ICT. Novice technology users also resisted change as it took too much time, they feared failure, and the curriculum and school administration did not support ICT use.

While a number of negatives were highlighted, the key is to recognize these challenges and view them as opportunities for future improvement. Through teacher training (both on how to use and how to teach with technology), attention to the curriculum and the creation of peer-to-peer learning communities the potential for ICT and e-learning can be realized.

These case studies and the authors’ experience indicate that there are some particular activities in e-learning programs that are remarkably successful—leading to e-learning being fully integrated into teaching, and encouraging educators to sustain and expand the use of e-learning. The program activities that worked well and were key to successful programs include:

- 6) the integration of e-learning into the curriculum
- 7) a focus on training teachers to both use and teach with technologies,
- 8) the establishment of a strong pedagogical foundation for e-learning to assist teachers in integrating it into their teaching
- 9) providing ongoing support for teachers
- 10) teachers had an opportunity to join a “community of practice.”

The most successful programs also took advantage of the fact that informal leaders often emerged from schools and classrooms. As an example, teachers participating in both the Algeria and Lebanon programs became the innovators and change agents within their schools. They embraced e-learning and their use of e-learning in classrooms encouraged others to explore the

potential it provides. These teachers encouraged the excitement and technology skills that students brought to their classrooms.

B. Key components of successful programs

This section provides additional information on some of the key components of successful e-learning programs. Selecting only a few components to highlight is challenging and involves an examination of a broad range of issues with each interdependent upon the other. Although particular components may assist in providing success, a sustainable program requires a multi-level approach. This would include:

- Policy
 - National ministerial levels
 - District and local levels
- Standards
 - Teacher standards
 - Student standards
 - Administrator standards
- Curriculum
- Infrastructure
 - Hardware, software
 - Electricity
 - Connectivity
 - Technical support
- Professional Development
 - Pre-service teacher training programs / colleges of education / teacher training colleges
 - In-service teacher training
 - Formal training
 - Informal training
 - ICT training
 - Training for how to use technology
 - Training for how to teach with technology
- Instructional Resources.

Although all the above items are important, the components below—teacher training, teacher standards and communities of practice—have been chosen to be further discussed in this paper due to their relevance for planning new programs.

1. Teacher Training and Professional Development

In addition to investments in ICT infrastructure, computers and learning management systems, countries also reported the importance of investing in one of their most important resources - teachers. In a large international study, nearly half of the countries reported providing online professional development for improving teacher skills and providing interactive collaborative tools to foster the development and sharing of instructional materials and strategies among teachers. Almost all countries also reported providing digital instructional resources for teachers through websites, online portals and learning management systems, often partnering

with commercial publishers for their development (Bakia, Murphy, Anderson, & Estrella Trinidad, 2011).

Research indicates that professional development for teachers, including initial training and ongoing support, is a key factor in supporting successful change in educational practices, including development of e-learning. The Second Information Technology in Education Study, an international study of ICT and pedagogical practices within secondary schools in 22 countries, indicates “the provision of ICT-PD (professional development) activities is a major means of improving teachers’ competence and confidence in using ICT in their teaching (p. 194, (Howie, Muller, & Patterson, 2005).” Research undertaken in Malaysian secondary schools showed that even older teachers do well implementing e-learning with appropriate training and support (Lau & Sim, 2008).

Governments of African countries, such as Nigeria, have realized the important role of continuous teacher professional development in reaching their national educational goals. In their Roadmap for the Nigerian Education Sector, government officials outline their plan to implement a National Framework for Continuing Professional Development for teacher (Egwu 2009). Teacher professional development is a critical component in addressing the challenges that African nations, including Tanzania, face within secondary education. Teacher support and training are necessary strategies to help address teacher shortages, particularly in math and science, absenteeism, and inequalities in education from urban to rural areas (Baker, 2010; MoEC, 2010). In Tanzania educational leaders within government identify capacity building and teacher professional development as the “main instrument for bringing qualitative improvement in teaching and learning (Education Sector Development Committee, 2010, p. 30).”

In understanding the role of teacher professional development, it is crucial to consider that teachers need to know both “how to use” technology and “how to teach” with technology. Section II.A.1. above discusses the TPACT approach, for example. Zhang (2003) and Goldman (2003) note that, unless there is a strong pedagogical foundation for ICT use, teachers will accommodate the use of ICT rather than assimilate into the curriculum. They note that the acquisition of technology skills does not translate into a change in teaching and learning. They suggest two guiding principles:

- 1) Teachers must be the pedagogical ICT leaders. Imposing the use of technology upon a teacher often results in the teacher using technology only for personal productivity (writing letters, taking attendance, etc.). Teachers are more apt to adopt and infuse technology into their curriculum when they assume responsibility for technology.
- 2) Acquisition of both ICT and pedagogical skills are crucial. Successful cases of ICT implementations occur where there is a conscious effort to integrate the acquisition of technology skills with cognitive and curriculum needs. Hence, there is a need for basic IT skill training and pedagogical training.

2. Standards – What teachers need to know and be able to do

With a focus on 21st Century skills and e-learning we must examine what teachers need to know and be able to do related to teaching and learning with technology. The International Society for Technology and Education (ISTE), an international professional association

representing educators worldwide, has established standards for students, teachers, and administrators. As we examine the key components of successful programs we should look carefully at what the ISTE standards indicate for teachers. The standards (Annex 5) state that teachers should:

- 1) Facilitate and Inspire Student Learning and Creativity. Teachers should use their knowledge of subject matter, teaching and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments
- 2) Design and Develop Digital-Age Learning Experiences and Assessments. Teachers should design, develop, and evaluate authentic learning experiences and assessments incorporating contemporary tools and resources to maximize content learning in context and to develop the knowledge, skills, and attitudes as related to the standards for students.
- 3) Model Digital-Age Work and Learning. Teachers should exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society.
- 4) Promote and Model Digital Citizenship and Responsibility. Teachers should understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behavior in their professional practice.
- 5) Engage in Professional Growth and Leadership. Teachers should continuously improve their professional practice, model lifelong learning, and exhibit leadership in their schools and professional community by promoting and demonstrating the effective use of digital tools and resources.

3. Communities of Practice – Connecting the Educational Community

The concept of “communities of practice” is not new and teachers for many years and generations have taken advantage of opportunities to gather and share information and resources. Today the technological advances have expanded opportunities to connect and collaborate not only with local teachers but also with a larger community of teachers, teacher educators, administrators, and a larger global community of educators. According to Bakia et al. (2011) there is a trend towards facilitating and encouraging the development of online communities of practice among educators. They report, “Added-value elements of online communities of practice include the ease of asynchronous communication, the inclusion of participants from a large geographic area, the ease of access, the digital archiving tools, and the materials and discussions that were posted or took place in the past.” (p. 38).

Communities of practice are an emerging trend and provide interactive, collaborative models for material development and sharing. The community of practice allows participants to share information and resources and learn from one another. Through the process of sharing information and experiences with the group, members learn from each other. Communities of practice can exist online through interactive discussion forums or in real life during group planning periods in schools, during lunch or other designated times. Communities of practice can also use blended techniques, leveraging both face-to-face interactions and online tools and discussions (Means et al. 2010; Bakia et al., 2011).

A community of practice is based on the need to build capacity among educators for continued learning, innovation, and adjustment. Rather than simply importing ideas and strategies from elsewhere, the goal is to help educators find what is most effective for the most important issues within their context. Accordingly, these communities will draw upon the expertise of those in other areas, and then adapt and apply those lessons to their own context. To build such a community, it is necessary to develop a sense of membership, emotional safety, belonging, and personal investment (McMillan and Chavis, 1986).

An excellent example of a community of practice is cited in the 2011 IETE report:

“The Flemish Belgian Ministry has consistently favored open-source solutions, and in 2002 it created its own open-source portal, KlasCement, as a central access point for c. Since its creation, the portal has expanded to include over 60,000 members and 13,000 contributions. Learning resources available via the portal include articles, documents, websites and software. Because nearly all of these are freely available and non-commercial in nature, the quality of the service depends upon user-generated contributions and feedback. The government has thus developed an incentive system to encourage teacher participation.” (p. 38).

Another example cited in the IETE (2011) report is New Zealand. Their portal includes interactive Web 2.0 technologies including blog pages, discussion forums, and a community page that discusses various software applications to improve teaching, tools for assessing student knowledge, and a professional learning community that discusses best practices. In Africa, SchoolNet Africa is a pan-African education portal promoting education through ICT in African schools and provides information to school administrators, teachers and learners.

In sum, the importance of establishing communities of practice cannot be overemphasized. Whether online or on-site, a community of practice provides opportunities for teachers, students, administrators, researchers, teacher educators, parents, policymakers, and other stakeholders to share their knowledge, best practices, and instructional resources. A community of practice also encourages new pedagogical strategies, innovative uses of technology, and supports innovation. And finally, it allows teachers and other stakeholders to learn from within their own local community and address the educational needs they face daily in the classroom.

V. Conclusion

Governments and donors in developing countries realize the critical importance of education for economic and social development. Many especially in Africa are now implementing ambitious plans to rapidly increase the number of schools. This investment is leading to significant progress in increasing the quantity of schools and students, and the next challenge is to update the curriculum and improve the quality of education. Governments are turning to e-learning in this endeavor. Many have started e-learning programs and are putting computers into schools. This report has attempted to provide a compilation of research on e-learning impacts and to discuss promising practices to inform new and on-going e-learning programs.

This paper synthesized literature on the uses and impacts of e-learning in developing countries, particularly in Africa. e-Learning is a term that encompasses a broad array of content

and instruction methods, and that has come to mean a new model of education involving revised curriculum, infrastructure, teacher professional development, textbooks, and exams to provide students with technology and “21st century skills” such as creative problem solving. A particularly useful aspect of ICT in education includes accessing the enormous amount of educational resources on the Internet and online libraries. The networking of teachers, students and others can also produce a lively community sharing information, ideas and strategies.

The short history of e-learning programs in developing countries has provided some key lessons in what activities work, and what produce sustainable programs. Many of the program activities that are successful are centered on the teacher: strong teacher training and professional development, mentorship, networking, and support to integrate e-learning pedagogical approaches into classroom practice and curriculum. The e-learning approaches need to be designed to fit the local situation and needs, for example content needs to be not only contribute to the curriculum and in the local language, but it also need to reflect cultural norms. Sustainable e-learning programs themselves require a multi-level approach from national level policy to Ministry curriculum revision to local infrastructure support. This involves strong national leadership and many participating actors. Critical national institutions include teacher training colleges, the Ministry of Education, and the private sector. International partners can play an important synergistic role providing technical expertise and financial support.

The actual impact of past e-learning programs on student achievement, and related national economic development and societal changes in developing countries is at this point difficult to estimate due to the paucity of quantified research. Some research has indicated that certain types of e-learning approaches, especially those that blend more traditional teacher centered teaching with technology, and technology that encourages student interaction with the content, does improve student learning. Cross-country comparison research finds significant impacts of especially secondary and tertiary school education on economic development, and indicates that improved education (especially in science and technology) does lead to a better workforce and higher incomes of graduates. What is needed is research that follows e-learning graduates and others over time to identify how strong the e-learning impact is, and what educational factors are particularly effective. Similarly, the impact of e-learning on societal factors can only be indirectly inferred. Education itself does result in a significant improvement in health, especially in girls and women. The more education, the larger the effect. It also reduces poverty, improves self esteem and decision making power. Societal factors clearly shape the potential success of e-learning programs, however. Geographical location, poverty and gender currently have a large role determining access to education, especially secondary school education. Access to ICT parallels that of education. ICT and good schools are usually concentrated in places with better infrastructure and connectivity—whereas rural and poor areas are where the assistance provided by e-learning is most needed and can make the largest difference. It requires specific planning, and more effort and resources to deliver e-learning to underserved areas and people.

Despite the complexities, the authors feel that enough has been learned from a pedagogical, technical and socioeconomic perspective to be able to design a successful e-learning program that methodically addresses the challenges, and that provides a platform for e-learning’s transformative effect.

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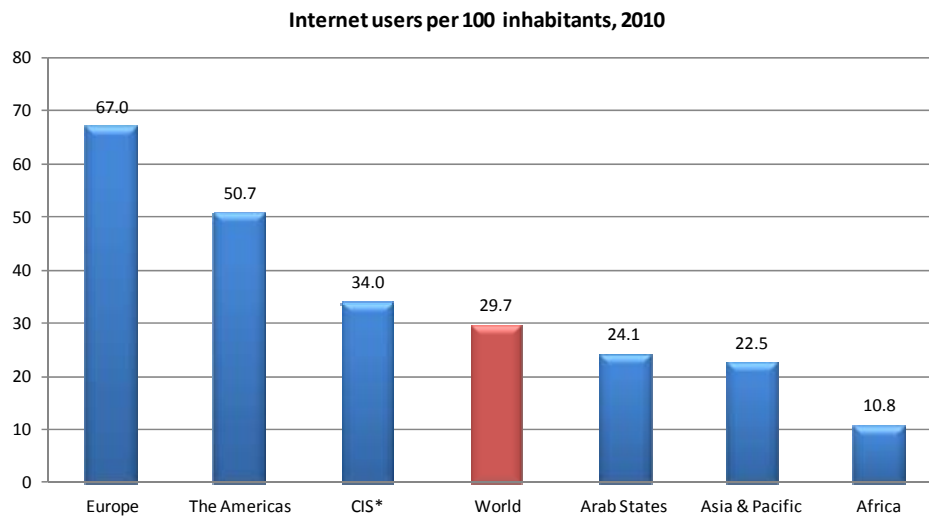
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ANNEX 1: Internet Availability by Continent.

Figure 1. Internet Users by Continent, 2010. Source: ITU 2011.

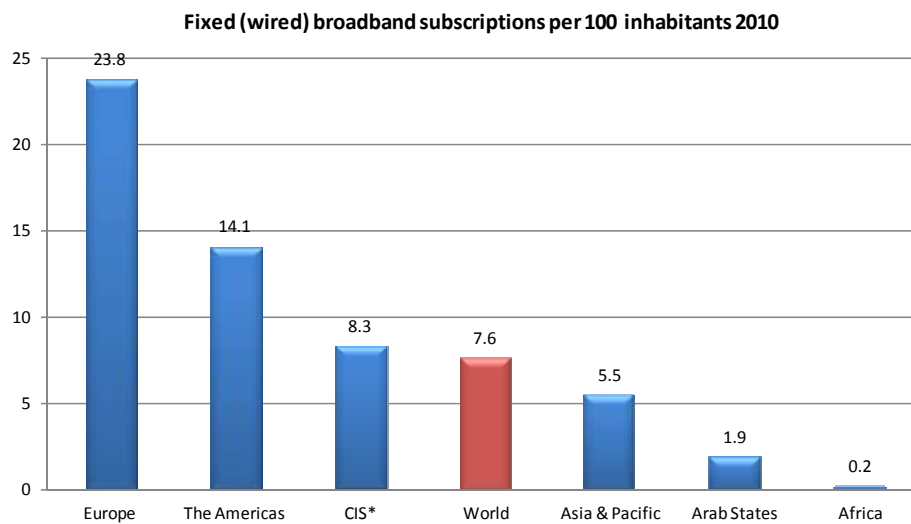


* Commonwealth of Independent States

Regions are based on the ITU BDT Regions, see: <http://www.itu.int/ITU-D/ict/definitions/regions/index.html>

Source: ITU World Telecommunication /ICT Indicators database

Figure 2. Broadband Subscriptions by Continent, 2010. Source ITU 2011.



* Commonwealth of Independent States

Regions are based on the ITU BDT Regions, see: <http://www.itu.int/ITU-D/ict/definitions/regions/index.html>

Source: ITU World Telecommunication /ICT Indicators database

ANNEX 2: Enabling and Constraining Features of ICT in the Tanzanian Educational System. Source: Hare 2007.

Factors	Enabling Features	Constraining Features
<i>Policy framework and implementation</i>	The new policy, when enacted and implemented, will help guide the development of ICT in education and therefore make the ministry assume leadership	The lack of a policy framework has hindered the uptake of ICT in education to date which contributed to the limited active promotion of ICTs in education within the Ministry of Education .
<i>Infrastructure and cost of bandwidth</i>		Despite the liberalisation of the telecommunications sector, the cost of bandwidth is still out of reach of many schools. Rural schools that are out of the national telecommunications network need to use expensive satellite technologies.
<i>Language of the Internet</i>	There is an increasing interest in developing online content in Kiswahili and some applications now come with Kiswahili dictionaries. The advent of open source software has helped localise ICTs and the Internet and therefore increased access.	Language has been identified as one of the major inhibitors of ICT use in Tanzania. A majority of the population is comfortable in Kiswahili and only learns English in later years in late primary school or early secondary school.
<i>Electricity</i>		The national electricity grid is still limited to commercially viable areas missing out most of the schools, which are in the rural areas. This, coupled with major breakdowns and load shedding, has increased the cost of owning ICT infrastructure.
<i>Tutor technicians</i>		ICT in education is still a new concept. The teachers- colleges are now training teachers in ICT . A lot more effort will be required to give in-service training to teachers in ICT.
<i>New technologies</i>	There is proliferation of new technologies that are promising to drastically lower the cost of entry and ownership of ICT in schools. These include open source software and Wireless Connectivity solutions using GSM networks, which have a wider coverage in the country.	

ANNEX 3. Tanzania Secondary School Education Graphs.

Figure 3. Pupil/ Teacher Ratio in Tanzanian Schools, 1980-2006. Source: UNICEF 2008.

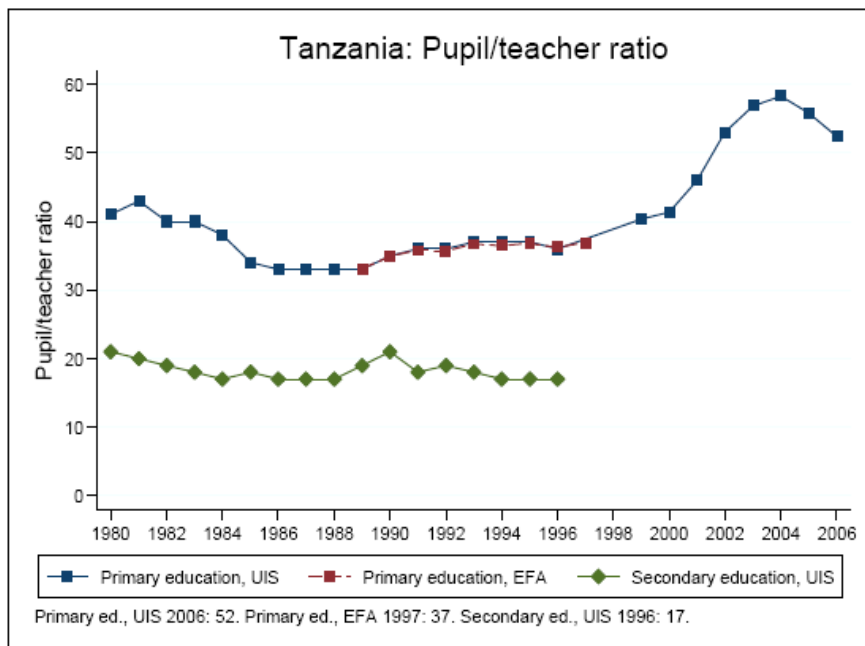
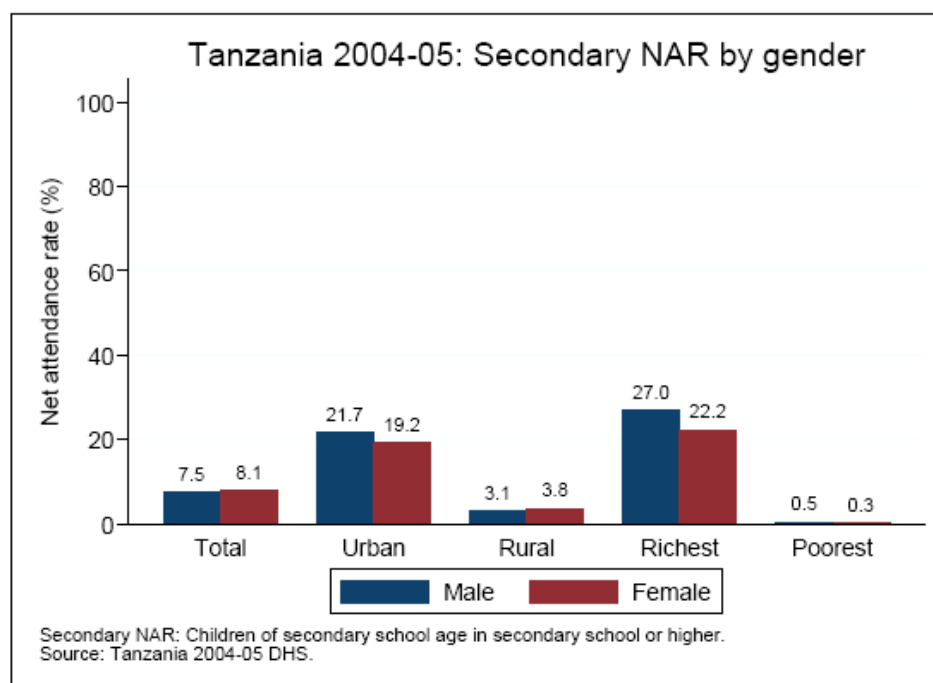


Figure 4. Secondary School Attendance in Tanzania by Gender, Urban/Rural and Wealth Group. Source: UNICEF 2008.



ANNEX 4: International e-learning actors in developing countries.

International Institutions

InfoDev (www.infodiv.org) is a program within the World Bank Group that promotes the use of primarily ICT technologies for entrepreneurship and education in developing countries. Its education program aims to produce knowledge resources on case studies, best practices and lessons learned in ICT4E, and it has produced a series of reports that are available on its website. It has also produced a toolkit for education policy makers and others to plan and evaluate ICT education development programs.

World Bank: In addition to InfoDev (see above), the World Bank supports many programs and produces reports related to ICTs and education. One example would be the African Virtual University (AVU), an online education portal. The main page on ICT and Education from the World Bank's Education web site can be found at <http://www.worldbank.org/education> and clicking on "ICT and Education".

eLearning Africa (<http://www.elearning-africa.com>) is Africa's largest annual conference on education and technology. It provides a forum for discussion and networking. At the sixth annual conference in 2011, 1,702 participants from over 90 countries from Africa and elsewhere attended. It was hosted by the Government of Tanzania in Dar es Salaam. The conference was held in English, French and partly in Kiswahili. The seventh eLearning Africa conference will take place in May 2012 in Cotonou, Benin.

International Telecommunications Union (ITU) is the United Nations' specialized agency for ICTs. It allocates global radio spectrum and satellite orbits, develops technical standards for ensuring that networks and technologies interconnect, and works to improve access to ICTs to underserved communities worldwide, particularly in developing countries. This includes technical capacity building, and disseminating information on trends and impacts of ICTs in development (<http://www.itu.int/en/pages/default.aspx>).

UNESCO (United Nations Education, Science and Cultural Organization; <http://www.unesco.org/new/en/unesco/themes/icts/>): UNESCO's global network of offices, institutes and partners provide countries with resources for elaborating ICT in education policies, strategies and activities. The UNESCO Institute for Information Technologies in Education (IITE) specializes in information exchange, research and training on the integration of ICT in education. This includes Open Access modalities, building communities of practice, global digital libraries and resource centers and digital learning tools. The Bangkok ICT in education office website has an e-library of ICT in education publications and other resources (<http://www.unescobkk.org/education/leading-the-international-agenda/ict>).

UKAID/ DFID, The Department for International Development in the United Kingdom, has been a leader in supporting research into appropriate uses of ICTs in the education sector in developing countries, and the related issues and challenges. See informational resources at <http://www.dfid.gov.uk/research/imfundo.asp> and the Eldis large platform of documents related to development at <http://www.eldis.org/>.

The Development Gateway was initiated by the World Bank and later became an independent foundation. The Gateway's "dgCommunities platform" hosts a set of online communities of practice focused around 30 development topics. The communities enable knowledge-sharing (over 50,000 postings), peer networking and collaboration for development professionals and others working in the field. The Development Gateway sponsors two on-line "communities" related to ICT and education: e-Learning (<http://topics.developmentgateway.org/elearning>) and Open Educational Resources (<http://topics.developmentgateway.org/openeducation>) which is a clearinghouse for a wide range of OERs, including learning content, learning tools, and implementation resources. It also support Zunia, a knowledge sharing platform with e-learning information (<http://zunia.org/cat/e-learning-1/>).

USAID (the United States Agency for International Development) has the "dot-EDU" information and communication technology (ICT) program to assist developing countries in strengthening educational systems that improve quality, expand access, and enhance equity through applications of digital and broadcast technologies (http://www.usaid.gov/info_technology/dotcom/dotedu.html).

Examples of private corporations involved in e-learning

Cisco

IBM

Intel (Intel Learning Series software and Classmate PC)

Microsoft (Technology for Emerging Markets)

Sun Microsystems

Small sample of international NGOs involved in education in developing countries

Care

Creative Associates

Oxfam

Save the Children

World Learning

World Vision

Online courses and information

The Khan Academy has a library of over 2,400 videos covering topics from arithmetic to physics, and 180 practice exercises (<http://www.khanacademy.org/>).

YOUTUBE EDU hosts more than 125,000 free instructional videos from universities and independent educators (<http://www.youtube.com/education>).

SchoolNet Africa is a pan-African education portal promoting education through ICT in African schools that provides information to school administrators, teachers and learners (<http://www.schoolnetafrica.org/>).

ANNEX 5. Technology Standards for Teachers of the International Society for Technology in Education (ISTE). Source: <http://www.iste.org/standards.aspx>.



The ISTE NETS and Performance Indicators for Teachers (NETS•T)

Effective teachers model and apply the National Educational Technology Standards for Students (NETS•S) as they design, implement, and assess learning experiences to engage students and improve learning; enrich professional practice; and provide positive models for students, colleagues, and the community. All teachers should meet the following standards and performance indicators. Teachers:

1. Facilitate and Inspire Student Learning and Creativity

Teachers use their knowledge of subject matter, teaching and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments. Teachers:

- a. promote, support, and model creative and innovative thinking and inventiveness
- b. engage students in exploring real-world issues and solving authentic problems using digital tools and resources
- c. promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes
- d. model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments

2. Design and Develop Digital-Age Learning Experiences and Assessments

Teachers design, develop, and evaluate authentic learning experiences and assessments incorporating contemporary tools and resources to maximize content learning in context and to develop the knowledge, skills, and attitudes identified in the NETS•S. Teachers:

- a. design or adapt relevant learning experiences that incorporate digital tools and resources to promote student learning and creativity
- b. develop technology-enriched learning environments that enable all students to pursue their individual curiosities and become active participants in setting their own educational goals, managing their own learning, and assessing their own progress
- c. customize and personalize learning activities to address students' diverse learning styles, working strategies, and abilities using digital tools and resources
- d. provide students with multiple and varied formative and summative assessments aligned with content and technology standards and use resulting data to inform learning and teaching

3. Model Digital-Age Work and Learning

Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society. Teachers:

- a. demonstrate fluency in technology systems and the transfer of current knowledge to new technologies and situations
- b. collaborate with students, peers, parents, and community members using digital tools and resources to support student success and innovation
- c. communicate relevant information and ideas effectively to students, parents, and peers using a variety of digital-age media and formats
- d. model and facilitate effective use of current and emerging digital tools to locate, analyze, evaluate, and use information resources to support research and learning

4. Promote and Model Digital Citizenship and Responsibility

Teachers understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behavior in their professional practices. Teachers:

- a. advocate, model, and teach safe, legal, and ethical use of digital information and technology, including respect for copyright, intellectual property, and the appropriate documentation of sources
- b. address the diverse needs of all learners by using learner-centered strategies and providing equitable access to appropriate digital tools and resources
- c. promote and model digital etiquette and responsible social interactions related to the use of technology and information
- d. develop and model cultural understanding and global awareness by engaging with colleagues and students of other cultures using digital-age communication and collaboration tools

5. Engage in Professional Growth and Leadership

Teachers continuously improve their professional practice, model lifelong learning, and exhibit leadership in their school and professional community by promoting and demonstrating the effective use of digital tools and resources. Teachers:

- a. participate in local and global learning communities to explore creative applications of technology to improve student learning
- b. exhibit leadership by demonstrating a vision of technology infusion, participating in shared decision making and community building, and developing the leadership and technology skills of others
- c. evaluate and reflect on current research and professional practice on a regular basis to make effective use of existing and emerging digital tools and resources in support of student learning
- d. contribute to the effectiveness, vitality, and self-renewal of the teaching profession and of their school and community