How Information and Communications Technologies (ICT) impact on trends and future educational innovations – the implications for higher education in Africa and the RUFORUM Network

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Introduction

Developments in information and communication technologies (ICT) continue to impact on how universities approach teaching, learning, collaboration, and research. ICT can help universities do their business more effectively and efficiently – by changing how teaching, learning and research are done to increase access, reduce costs and expedite degree completion. But ICT is not an end unto itself; rather it is a tool to accomplish a set of objectives.

This paper discusses educational innovation in ICT and its potential to influence how African universities, especially the RUFORUM Network, can meet their mission.[1] The paper summarizes the e-readiness status of the RUFORUM network,[2] provides a definition for educational innovation, offers a few noteworthy trends and innovations, and assesses the implications for African universities.

The importance of ICT for the RUFORUM Network

Key findings from RUFORUM ICT studies

- In 2009 86 percent of the RUFORUM universities surveyed had a campus backbone; 58 percent had ICT policies in place; and 60 percent had central ICT units to manage and monitor ICT projects. However, the Colleges of Agriculture lagged behind in use of ICT for teaching, learning, and research in comparison to other disciplines within the university.
- In 2011 59 percent of the 29 universities surveyed had a rationale in place for e-learning within an explicit institutional plan; 45 percent had e-learning policies compared to 26 percent in 2009; and 32 percent had e-learning units. The situation for the Colleges of Agriculture, however, remained the same—teaching content in agriculture was almost negligible on institutional learning management systems.

RUFORUM understands the centrality of ICT to the teaching, learning, and research process, and has worked to assist member universities change the way they view pedagogical practices. As a start, RUFORUM conducted an analysis of ICT infrastructure and e-learning readiness in RUFORUM institutions in order to establish a baseline.[3] This was followed by a more comprehensive assessment in 2009.[4] In 2011, RUFORUM surveyed all member universities on their e-learning capability.[5]

Any discussion of appropriate use of ICT in educational transformation must be take into consideration where RUFORUM

[1] http://www.ruforum.org/content/our-member-universities

[2] KENET, the Kenya Education Network Trust, has assessed e-readiness in East African universities for several years. It has developed a series of indicators and quantifiable targets or benchmarks. Go to http://ereadiness.kenet.or.ke:8080/ereadiness/.

[3] Nodumo Dhlamini, *Analysis of Existing ICT Infrastructure & Readiness for E-learning*, RUFORUM, 2007, http://repository.ruforum.org/documents/analysis-existing-ict-infrastructure-readiness-e-learning

[4] CGNET, *Situation Analysis of ICT Capability and Infrastructure in RUFORUM Universities*, RUFORUM, 2009, http://repository.ruforum.org/documents/analysis-existing-ict-infrastructure-readiness-e-learning

[5] Nodumo Dhlamini, *The 2011 Results of the E-learning Capability Survey in RUFORUM Member Universities*, RUFORUM, 2011, http://repository.ruforum.org/documents/analysis-existing-ict-infrastructure-readiness-e-learning

universities are coming from and wish to go.

Defining educational innovation

Generally speaking, educational innovation introduces new ideas, methods, or technologies that can improve performance and are ultimately scalable. When incorporated properly, these innovations "can offer flexibility to enable institutions to adapt more readily in a constantly changing environment…"[6] Although implementing technology improvements in ICT infrastructure and equipment are important, they are only the foundation on which institutions of higher learning can build new ways of teaching, learning, and research. Innovation cannot take place without transforming the educational process and policies.

Elliot Washor (2009), the co-founder of Big Picture Learning, encapsulated why innovation is so important to educational systems:

> From our perspective, innovation means first different, then better. That is, innovating is a fundamentally different way of doing things that result in considerably better, and perhaps different, outcomes. Both the 'different' and the 'better' must be significant and substantial. Educators need to think of innovating as those actions that significantly challenge key assumptions about schools and the way they operate. Therefore, to innovate is to question the 'box' in which we operate and to innovate outside of it as well as within.

Thus, rather than focus on innovation for the sake of change or ICT as a goal for its own sake, we must understand the educational sector's needs – its goals, challenges, systems, processes, value networks, standards and regulatory environment. It is also essential to be "daring" enough to try out new methods, tools and processes.

Why innovate in the field of education

Students live in an ever-changing world. Teaching staff cannot stand still; otherwise they will be left behind. The traditional architecture for higher education where the professor relies on standing in front of students and "dishing out notes" no longer works because the students have access to vast amounts of online information (both poor and high quality) related to the courses that are taught in schools, colleges and universities. Educational institutions are in a learning revolution characterized by an open culture, a fundamental shift in how knowledge is created and used, and the need for new skills. Higher education in many countries now routinely use digital content, different ways to engage learners, classrooms without walls, adaptive university policies and systems, and shifting standards for measuring quality. African university leaders must keep current on these new developments to assess which of them will help improve the quality of learning, research, and community engagement that takes place within their institutions.

Today's learners want an education that meets their need to be employable after they graduate and that will provide them with opportunities to learn about what is happening around the world. They require their professors to be innovative, and to make learning environments more attuned to the needs of the job market. Today's learners exist in a borderless world offering growing Internet connectivity, data and mobility. In Africa students are already choosing to access knowledge and participate in discourse on a global scale.

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[6] Innovation in Higher Education: Implications for the Future, Susan C. White, Theodore S. Glickman, page 97, http://cyber.law.harvard.edu/communia2010/sites/communia2010/images/White_Glickman_2007_Innovation_in_Higher_Education-_Implications_for_the_Future.pdf

Trends supporting educational innovations

The table below describes some key trends relevant to training and research in agricultural that facilitate educational innovations. These trends are described in the Core Education blog.[7] In addition, we have inserted footnotes for additional resources that describe some of these trends in more detail.

Trend	Drivers	Opportunities in agriculture
Three Dimensional (3D) Tools & Applications	• Growth of 3D tools and applications • 3D is a more accurate way to learn about the world because the world is 3D • 3D gives the chance to work in the abstract, virtual & imaginary worlds.	• 3D printing technology can enhance practical training. • Farm machinery manufacturers use 3-D printers to make prototypes of parts. This is already being done in the US and is being used in the developing world for smallholder farmers, including Africa.[8] • Facilitating students experiences in the use of tools that will allow them to think in three dimensions • African students must learn how to use 3D technologies—they are already the wave of the future.
Openness[9] Open access, open source software, open educational resources, open data, open standards	• Creative commons licensing, which permits sharing and adapting resources without requesting permission • Increased online and open access and availability, which increases visibility for African research • Open source, which does not require license fees • Global competition among institutions	• Open-learning environments • Innovations in teaching and learning through OER, MOOCs, and other forms of openness • Different kinds of recognition for successfully completing courses or modules, such as digital badging systems. Digital badges are being used in the US already as recognition for ongoing education of students. They can also impact how educational institutions evaluate their programs.[10]

[7] http://blog.core-ed.org/blog/

[8] Go to "3D Printing for Agriculture," Todd Haltermann, 3D Printer World, March 19, 2014, http://www.3dprinterworld.com/article/3d-printing-for-agriculture and the 3D for Ag Development Program website, http://3d4agdev.org/

[9] RUFORUM is already collaborating extensively with Network members on open access, OER and other forms of openness. The RUFORUM institutional archive is open access. Go to http://ruforum.org. Visitors will find many resources relevant to open access and OER

[10] The University of California-Davis created a badging system for a new undergraduate major in sustainable agriculture and food systems. The final product, which went live with a small pilot group this fall, is more about competency-based education than alternative credentials. Go to: http://www.insidehighered.com/news/2014/01/03/uc-daviss-groundbreaking-digital-badge-system-new-sustainable-agriculture-program#sthash.6QiL4gng.dpbs.

Trend	Drivers	Opportunities in agriculture
Learning Analytics[11] which involve data analysis Collecting, analyzing and reporting of large datasets relating to learners and their contexts in order to improve teaching and learning	• When used properly, analytics can provide valuable insights to inform strategic decision-making on efficient resource allocation to meet university goals to promote excellence in teaching and learning. • Learning Management Systems (LMS) can provide that data. • Need to move past analytics for the sake of analytics. The article footnoted below gives examples.	• The US is pioneering the use of big data and analytics in agriculture. For example--Solum[12] brings big data analysis to help farmers increase crop yields. "The company provides hardware and cloud-based technology to give farmers better insights into their soil."[13] • Analytics provide increasingly personalised, meaningful, engaging learning experiences for students. • Analytics can track learner progress, get early intervention information as soon as possible, and to make informed decisions about strategies that are most likely to make a difference for that student. • Analtyics can strengthen partnerships between educational institutions, the students, parents and governments / future employers
Ubiquitous Learning Learning is available to us 24 hours a day, 7 days a week, almost anywhere in the world.	• Social media • always on, always connected • mobile technologies • cloud computing • online services • wireless • Learning works best in the right context and the right time. Ubiquity helps learning be right there.	• Embracing this new way of learning • Innovating on how to spend time in the classroom • Designing institutional network infrastructure to accommodate the flood of student-owned mobile devices being connected

[11] Go to Macfadyen, L. P., & Dawson, S. (2012). Numbers Are Not Enough. Why e-Learning Analytics Failed to Inform an Institutional Strategic Plan. *Educational Technology & Society*, 15 (3), 149–163, for an assessment of learning analytics, including how they should be used.
[12] http://solum.ag/
[13] "Big Data Moves Down to the Farm," Noreen Seebacher, All Analytics, 9/11/2012, http://www.allanalytics.com/author.asp?section_id=2220&doc_id=250468

Trend	Drivers	Opportunities in agriculture
Mobile Technologies	• Growth of wireless technologies • The convenience brought by mobile technologies – coverage, anytime, anywhere • Development of applications that run on mobile gadgets • Growth is smart phones and other gadgets • Mobile and smart phones are now ubiquitous in Africa	• Use of mobile phones as learning platforms – providing access to learning content • Possibility to engage learners • Mobile phones at the community level—students can upload data relevant to farmers • Mobile phones can help farmers and pastoralists keep track of herds. • Mobile phones can help farmers learn wholesale retail prices. • SMS messaging has a range of functions for students, farmers, and local communities. • Mobile technologies are already in use throughout Africa, including in the RUFORUM network.
Cloud Computing	• Mobility • Business Continuity • Handling resource shortages • Managing application upgrades • Coping with technological uncertainty and change	• Hosting of learning platforms and ensuring their availability anytime and anywhere • Reducing focus on IT support issues and focusing on the core business of teaching and learning

Trend	Drivers	Opportunities in agriculture
Game Based Learning	• Advances in gaming technologies • Need to innovate and accommodate different learner needs	• Facilitate experimentation, exploration and simulation of real world experiences through game based learning techniques. • Digital game-based learning is used to teach visual basic program design courses at Qingdao Agricultural University in China. This is a required course. Students surveyed reported that their understanding of the subject matter improved with game-based learning.[14] • The US Department of Agriculture has given Alabama A&M University a grant to develop a mobile lab (Water Wheels) that will enhance the quality of extension water conservation education programs. Water Wheels will contain 3-D monitors and computers for the Interactive Game Based Learning Environment (IGLE) software that can be expanded to include dynamic programs on sustainable agriculture, science, global climate change, and other environmental issues.

Current technologies that can impact on postgraduate training in agriculture right now

There are a number of opportunities to be explored for implementation:

- *Remote Desktop Computer Labs*—What about remote access to computers in an academic computer facility. This would allow users to access special class software and other resources from home or hostels. Remote desktop provides the ability to use all of the software available in the university computer lab without leaving home. Users can even print their work to their home printers or save it to their laptops. Remote computer labs are offered at many US universities. For example, the College of Agricultural, Consumer, and Environmental Sciences, a land-grant institution in Illinois, permits remote access to one of its computer labs.[15] North Carolina State University has also installed a virtual computer lab for its entire student population. The lab contains access to all of the software packages that they need, such as 3-D modeling tools and advanced statistical programs, but it exists on powerful computer servers. Faculty can install their own software packages; students have access whenever they want; and administrators say

[14] "Digital Game-Based Teaching in Visual Basic Program Design of Agricultural Universities: Application and Impact on Education Effectiveness," Zhao Chen and Huang Fang, Qingdao Agricultural University, International Conference on Education Technology and Management Science (ICETMS 2013), http://www.atlantis-press.com/php/pub.php?publication=icetms-13&frame=http%3A//www.atlantis-press.com/php/paper-details.php%3Fid%3D7116

[15] http://acf.aces.illinois.edu/remote/

that it was cheaper to build and maintain than physical labs. The idea has proven so popular and cost-effective that universities throughout North Carolina have bought into the system.[16] Would a virtual computer lab (VCL) make sense for any of the RUFORUM regional programs or for the RUFORUM network?

- *Virtual Microscopes*—If a VCL is not yet possible, what about virtual microscopes? The University of Delaware maintains a virtual microscope to teach beginning students how to use a microscope in order to improve their actual lab experience. This would probably be most useful to the RUFORUM network at the undergraduate level. The microscope has a Creative Commons license, so it is available to users right now.[17] There are other examples; this is just one.
- *Virtual Experiments*—What about virtual experiments? As just one example, the Massachusetts Institute of Technology (MIT) has developed a system to demonstrate concepts in genetics to students. MIT has developed a freely accessible program called StarGenetics, a Mendelian genetics cross simulator developed by biology faculty, researched-trained scientists and technologists. StarGenetics allows students to simulate mating experiments between organisms that are genetically different across a range of traits to analyze the nature of the traits in question. Its goal is to teach students about genetic experimental design and genetic concepts.[18]
- *Crop Simulation Models*—The University of Georgia is leading efforts to deploy a Decision Support System for Agrotechnology Transfer (DSSAT), a software application program that comprises crop simulation models for over 28 crops, including maize, rice and other crops relevant to Africa. The crop simulation models in DSSAT simulate growth, development and yield as a function of the soil-plant-atmosphere dynamics, and they have been used for many applications ranging from on-farm and precision management to regional assessments of the impact of climate variability and climate change. It has been in use for more than 20 years by researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 100 countries worldwide.[19]
- *Open Data*—what about using open data databases that are already available? The African Soils Information Service (AfSIS) is a digital soil mapping system that makes available accurate, up-to-date, and spatially referenced soil information to support agriculture in Africa.[20] As an example, we hope that in a short while RUFORUM cassava researchers and others will be using and feeding into the cassava open data project[21] A key question though is whether the RUFORUM network should consider designating the data collected through its research as "open?" Should RUFORUM be working in this area in the same way it does for open access?[22]

Future technologies that could impact on educational innovations

Some of the high-end future technologies that could impact teaching, learning, research and collaboration in Africa are described below:

1. **Multi-Touch Surfaces** are based on touch surface technology which is becoming cheaper and more advanced. There are now early concepts of multi-touch products that are predicted to change the classroom. Whole work surfaces can be manipulated with real-time

[16] Jeffrey R. Young, "A Computer Lab that Students Use but Never See," *The Chronicle of Higher Education*, May 30, 2008, http://chronicle.com/article/A-Computer-Lab-That-Students/11537. Also, go to the VCL home page for more information: http://vcl.drupal.ncsu.edu/.
[17] Go to http://www.udel.edu/biology/ketcham/microscope/ for a tour and to http://www.udel.edu/biology/ketcham/microscope/scope.html for the actual 'scope.
[18] http://star.mit.edu/genetics/index.html?gclid=CJiouam3y74CFfQbtAodsg8ARg
[19] http://dssat.net/
[20] http://www.africasoils.net/
[21] http://www.cassavabase.org/
[22] Go to Global Open Data for Agriculture & Nutrition: http://godan.info/

data and altered for completely different purposes. For example workspaces could be developed where agricultural students collaborate live with peers around the world and manipulate virtual objects right in front of them.

2. **Holographic Displays in** education could revolutionize distance learning as well as provide different spaces for simulation and experimentation. Students could recreate holographic scenarios, such as science experiments or scaled models that may be too expensive or dangerous to put together in the classroom. This type of technology could offer great educational value as well as helping younger students develop and master motor skills.

implications for Higher Education in Africa and the RUFORUM Network

Universities in Africa face challenges related to increased demand for their services while at the same time maintaining quality. It has become critical for African universities to keep *curricula* current and in line with the globalization of education. Experienced professors in the majority of African universities are aging; there is limited planning for replacement of retiring staff. The RUFORUM advocacy strategy continues to focus on highlighting problems related to limited investments in higher education by African governments. Limited funding to support African Higher Education has grossly hampered development of the required capacity to build Africa's own capacity for capacity development. RUFORUM platforms such as the Biennial conferences aim to increase the awareness for the need to support local and international partnerships that address critical capacity needs.

Universities in Africa would benefit from lessons that have been learned from the educational priorities and business models of universities such as Western Governors University in the United States. Western Governors was "designed using technology to provide education that is accessible, flexible, and affordable without compromising quality" The founders understood that "technology must take a transformational role in education in order to change the way we measure learning, expand the notion of how learning happens, and make possible learning that can take place anytime, anywhere."[23]

Statistics shared from RUFORUM network members suggest that RUFORUM universities have limited skills and experience in order to harness ICT and realize their positive impact on intended educational outcomes. RUFORUM reviews have also brought to light that there is limited infrastructural capacity to deliver high quality education and learning experiences in the network universities – this includes challenges with laboratory/scientific equipment, bandwidth, reliable power supplies, etc. Even so, several universities in the RUFORUM network have made commendable strides in adopting educational technologies. However, much remains to be achieved so that RUFORUM universities can be counted among the most progressive and innovative universities in Africa and elsewhere in the world.

Recommendations to the RUFORUM Vice Chancellors and other university leaders

1. As a network of African universities we should prioritize identifying which educational innovations can work in an African context and then work towards applying them. We must build the discipline, infrastructure and incentives to identify systematically breakthroughs, then assess them for relevance and support those that are pertinent.

[23] "Western Governors University, Robert W. Mendenhall, chapter nine in *Game Changers*, Educause, 2012, http://www.educause.edu/library/resources/chapter-9-western-governors-university

As two examples, when the iPad was introduced in 2010, many experts thought it was a "toy." Now iPads and other tablets are ubiquitous, with many educational and research applications from primary school up through university. The fact that cost of tablets has declined has not hurt. What about augmented reality eyewear, such as Google Glass? Here, too, not many people can think of "real-life" or educational applications for Google Glass. But in the United States, surgeons are beginning to experiment with Google's latest piece of hardware. One Indian American surgeon is using the application to record and archive his surgeries. He plans to begin streaming live feeds of his operations to hospitals in India in order to train medical students there.[24] It's too early to know whether Google Glass applications will be relevant to research and training in agriculture in Africa, but it is incumbent on universities to keep abreast of developments and understand their possible significance. No one wants to promote a new learning technology, just because it's there. This is not an "IT" job. Rather it requires that IT staff collaborate with curriculum and other pedagogical experts to makes these decisions.

2. African governments must support and encourage funding for basic applied research to identify and promote educational innovations that have the potential to improve intended educational outcomes.

3. Substantial funding streams are required to facilitate the identification, evaluation and adoption of effective educational innovations that can be scaled out to improve the educational services of African universities.

Recommendations to the academic staff of African universities

As a way to begin adopting educational technologies more actively and keep abreast with trends, academic staff of African universities in Africa are encouraged to liaise with relevant staff and educational technology centers at their institution to learn more about using technology to improve teaching and learning. Steps to take include:

1. Think about identifying and using OER and open access resources in courses.
2. Encourage students to carry out online literature reviews and facilitate training for them in information literacy (through the library, perhaps).
3. Explore using social media (LinkedIn, Face Book, Twitter).
4. Start drafting your materials in e-format and make them accessible to students online and through the university intranet and Learning Management System; on CD or flash drives, through email; and on your blog or website, if you have either.
5. Record your lectures for sharing later
6. Use ICT tools to elicit feedback from students
7. Champion delivery of specific courses or modules online in collaboration with regional or international experts based elsewhere
8. Participate in an online course to understand what it means.

[24]"Google Glass Enters the Operating Room," Anahad O'Connor, New York Times, June 1, 2014, http://well.blogs.nytimes.com/2014/06/01/google-glass-enters-the-operating-room/?_php=true&_type=blogs&_r=0