

# Computer Science Research Capacity as a Driver of ICTD Innovation: Institutional Factors in Kenya and Uganda

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## ABSTRACT

Computer science (CS) is a core component of the Information and Communication Technologies for Development (ICTD) field, providing the technical underpinning of ICT innovations that aim to improve the livelihoods of members of poor and marginalized communities. Previous studies of ICTD research capabilities in Africa have begun to describe the current state of CS research, mostly through bibliometric analyses. However, there have been few studies that explore, in detail, the factors that influence how CS capabilities are being constructed in Africa, especially studies based on in-depth interviews and surveys. This note introduces a research project and presents preliminary findings that address this important gap in our understanding of ICTD innovation ecosystem. Based on over 20 semi-structured interviews with CS researchers; government policymakers; and representatives from donors, private companies and innovation hubs, we discuss our emergent findings that focus on how structural and institutional issues are linked to building CS capacity. We argue that structural and institutional factors – such as the relationship between CS departments and their parent universities, and the relationship between universities and the private sector – can be as large of roadblocks to building CS capacity as technical barriers. Because this note represents research work in progress, we conclude with a reflection on how the project will proceed as the research enters its main phase next year.

## Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computer and Information Science Education - *computer science education*; K.4.1 [Computers and Society]: Public Policy Issues; K.4.2 [Computers and Society]: Social Issues; K.7.2 [The Computing Profession]: Organizations

## General Terms

Management, Measurement, Human Factors.

## Keywords

ICTD, computer science, research capacity, institutional factors, policy, Africa, Kenya, Uganda

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## 1. INTRODUCTION

Computer science (CS) has been a core component of the Information and Communication Technologies for Development (ICTD) field, and it likely will continue to be so in the future [9, 13, 14, 19]. While ICTD research is thoroughly interdisciplinary [4], CS and the related areas of informatics, and information systems are the disciplines that produce the technical interventions which are the heart of ICTD innovations [6].

In the case of Africa, ICTD researchers have argued that *local* computer science capacity is lacking [11,12]. Gitau et al. found that African participation in ICTD research across both technical and non-technical disciplines is extremely low, making up only between one and nine percent of all ICTD contributions when one examines key publications and conferences [11]. The more technical ICTD disciplines, including CS, are at the lower end of this range. Furthermore, most of the technical work that is done by African ICTD researchers involves customization of ICTs based on knowledge, techniques, and technologies developed elsewhere, mostly in developed countries [12].

This lack of local CS and technical capacity is alarming because local technical capacity is extremely important. If Africans are not carrying out ICTD research, it is unlikely that ICT interventions will lead to positive social and economic outcomes appropriate and relevant to local contexts [16]. Furthermore, research done by outsiders is not seen as valid by policymakers and local practitioners in Africa [12]. Therefore, leading ICT practitioners are calling for Africa to build its own CS research capacities [15]. The importance of local technical capacity is also underlined by decades of research from development studies about the importance of local participation in development projects [5] and by social studies of science and technology that have shown how local contexts shape knowledge production [2,3].

The ICTD field has clearly laid some important groundwork (mainly through bibliometric analyses) in terms of understanding the current state of CS research in Africa and the implications of this state of affairs [11,12]. However, there have been few studies that explore, in detail, why this is so and how the situation is changing in Africa, especially studies based on in-depth interviews and surveys (for some exceptions, see [7, 20]). Indeed, Williams and Baryamureeba, computer scientists at Makerere University in Uganda, argue that more research is specifically needed on “factors that influence research excellence and vitality in computer science” [21, p. xi].

This note introduces a research project and presents preliminary findings that address this important gap in our understanding of the ICTD innovation ecosystem. Our project entitled ‘The construction of computer science research capacity in Kenya and Uganda: Innovation, Capacity, Policy Identity’ was recently

funded by the US National Science Foundation. While the main research will take place in summer 2014, background and preliminary research has been undertaken at various points over the last five years in Uganda and Kenya. Here, we present findings from this initial research that focus on how structural and institutional issues are linked to building CS capacity. Taking an innovation systems approach [10], we use the terms structural and institutional issues to refer to the policies and strategies of universities, governments, innovation hubs, non-governmental organizations (NGOs) and private companies that shape the interactions between these actors, and thus the production, diffusion and use of socially and economically useful knowledge [8]. Based on preliminary evidence from our work in Kenya and Uganda, we argue that structural and institutional factors can be significant roadblocks to building CS capacity, as significant as technical barriers (such as bandwidth and computing power).

The rest of the note is structured as follows. First, we introduce the methodology of the larger project and the preliminary research. We then discuss the findings from the initial research in Kenya and Uganda. We end with a discussion of our plans and issues we are facing as we move into the main phase of our research.

## 2. METHODOLOGY

The main goal of our larger research project is to understand how computer science capacity is being built in Kenya and Uganda and how this capacity is connected to socially and economically relevant local innovation. Nairobi, Kenya and Kampala, Uganda have been identified as key cities for emergent CS in sub-Saharan Africa.<sup>1</sup> The research specifically examines the computer science departments at prominent universities (especially Makerere University and University of Nairobi) as hubs of innovation systems [8,10]. We chose only two countries because it would be difficult to feasibly reach a detailed level of understanding with a larger pool of case studies. The two countries are similar enough that we can learn a great deal by comparing and contrasting some of the details in the cases.

The project concentrates on two research objectives: I) *Characterizing the innovation system*, including current capabilities and policy and societal contexts, and II) *Understanding system dynamics*, particularly how specific research priorities and innovation pathways are negotiated. Specific research questions focus on concepts of *capacity* and *identity*, including: Is sub-Saharan Africa building a self-sustaining computer science capacity that can be measured through trends in public and private funding, research output and quality, infrastructure and human capacity? How do government policies support CS? How do researchers negotiate entrepreneurial, scientific, and community development motivations and identities? Is CS creating unique research to address local social and economic needs?

The project includes three primary data collection activities that combine quantitative and qualitative methods: 1) a quantitative survey of computer science researchers and graduate students; 2) in-depth qualitative interviews with researchers as well as with

students, government policymakers, funders, entrepreneurs and staff of NGOs and innovation hubs; and 3) video ethnography [18] of everyday interactions between researchers and other actors that are nodes in the innovation system including students, community organizations and funders.

One of our methodological commitments is to conduct our research in very close collaboration with our African social scientist colleagues with whom we have been working for almost a decade. As mentioned above, we acknowledge the movement within the ICTD community which argues that ICTD research about Africa should be conducted by Africans as much as possible [11]. So although we do not consider ourselves ICTD researchers (rather we are social scientists who associate with technology studies and technology policy) this project has been designed – and will be carried out – in very close partnership with our African colleagues based in Uganda and Kenya.

Our preliminary research was conducted from 2006 to 2009 and again in 2012 and 2013 and consisted mainly of semi-structured qualitative interviews. Over 20 interviews were conducted with academics (including researchers and students) and other connected actors that are nodes in the innovation system such as members of the private sector, government officials, NGO staff members and staff at innovation hubs. The interviews covered topics including: motivation for research and projects, departmental/organizational mission and vision, metrics of success and failure, hardships and challenges, applications of research, and anticipated benefits of research and applications.

## 3. FINDINGS

Below we present preliminary findings that mainly address our first research objective: characterizing the innovation system. The themes we discuss are emergent, but give some understanding of the factors that shape existing CS research capacity.

### 3.1 Kenya

Thus far we have found little in terms of national policy frameworks specifically aimed at promoting CS in Kenya. Staff and faculty at University of Nairobi stated that the national ICT Board charged with leveraging and promoting the use of ICTs for development does not focus explicitly on building CS research capacity. The ICT Board does work with the School of Computing and Informatics (the CS department) at University of Nairobi. In fact, one of its members used to teach in the CS department. However, the interactions between the board and the department are mainly limited to providing funds for the university to conduct ad hoc consulting projects.

The director of the CS department at University of Nairobi explained that structural and policy issues seem to be hampering institutional and human capacity at the CS department at University of Nairobi. For instance, the Kenyan government's policy to provide free primary education in 2003 has created a huge influx of university students, which has forced faculty to spend more time teaching. At University of Nairobi, students accepted to the CS program must wait about 20 months before they can begin their studies. To clear this backlog, CS faculty have started teaching in the summer break, limiting time for research. In addition, when government decided to turn former technical colleges into universities to create more university spaces for students, many faculty at University of Nairobi left because they were offered higher salaries to teach at these new universities. These factors have constrained the amount and perhaps the quality of research that CS faculty are able to conduct.

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<sup>1</sup> We recognize that several cities in South Africa have an existing strong capacity for CS research and the project will examine how CS researchers in Nairobi and Kampala collaborate with South African researchers. The choice to focus on Nairobi and Kampala was made in order to examine CS capacities that are in earlier stages of emergence.

Strathmore University (also in Nairobi) represents another interesting case study of institutional attempts to build CS research capacity. In 2011, the university created iLab Africa, a CS and ICT research center. iLab is a quasi-independent organization. It is associated with the Faculty of Information Technology because it administers an MSc program. But the main purpose of founding the organization was to base Strathmore faculty within an independent center, thereby freeing them from much of their teaching responsibilities and empowering them to conduct research. However, in our interviews with iLab administrators they described that this institutional innovation has not straightforwardly led to increased research capacity. iLab is responsible for bringing in research contracts in order to raise funds to hire other instructors to teach the classes previously taught by faculty now in iLab. The pressure to bring in these funds can sometimes prevent researchers from publishing in academic journals because of confidentiality and intellectual property agreements, and because researchers are too busy executing projects and writing project reports to publish in journals.

Outside the University of Nairobi and Strathmore University, our preliminary research highlights how Nairobi provides a distinctive and dynamic environment for CS-driven innovation. Microsoft and Google have offices in the city. IBM Research also very recently opened a laboratory in Nairobi. Staff involved in this initiative stated that IBM plans to hire 15 PhDs in CS and related fields. To put this number in context, it rivals the number of CS PhDs at University of Nairobi and Strathmore University combined. In addition to universities and the private sector, there are several innovation hubs and business incubators in Nairobi that can support CS. These present an interesting contrast to universities in terms of institutional factors that influence the development of CS capacity. For instance, one of the most prominent innovation hubs in Nairobi, iHub, has an extremely flexible organizational structure. iHub does collaborate with universities, but is largely independent of formal educational bureaucracy. iHub recently created a unit to conduct research, both technical CS research and more applied ICTD research. According to our respondents who work at and with iHub, publishing is emphasized in this new unit, and there are plans to host a master class for CS graduate students (MSc and PhD) where research methodology will be taught.

### 3.2 Uganda

Thus far we have found several factors at play in the construction and persistence of computer science as an academic discipline at Makerere University in Kampala.

Institutional arrangements between the university and the CS department were crucial. Starting in the mid-2000s, the department was given authority to directly make its own partnerships and to receive funding directly from partners, without having to go through university-wide administration. This arrangement encouraged donors, especially from Europe, to make funds available. The CS department also found it could better track the funds it received and better direct funds to the desired activities.

Integrating international talent has also been a key factor for Makerere. CS leadership made a determined effort to recruit CS faculty from the Caribbean, Britain and other parts of the world. The openness to international faculty – and the willingness to pay higher-than-normal salaries to these faculty for short periods of time – by the CS department contrasted sharply with the general reluctance in other university departments to hire, even for short periods, non-African faculty. In the CS department, one foreign-

trained faculty member has stayed permanently and has played an important role in the emergence of a PhD program and in a setting research agenda.

The information technology community in Kampala, while focused on commercial applications of computer science, was open to building bridges with the CS department, especially in the area of supply adjunct faculty to the department. Commercial information technology in Kampala is centered around a small set of home-grown companies that build applications and services for mobile phones. These commercial aims loosely parallel the research agenda of CS at Makerere, which also emphasizes innovation around mobile phones.

## 4. CONCLUSIONS

We have focused here on structural and institutional issues that shape the construction of CS capacity in Kenya and Uganda. The relationships between CS departments (or centers) and their parent universities and how these relationships evolve over time appear to be a significant factor in understanding how CS capacity is being built. In addition, it seems that government policies are also important, however not in straightforward ways. At least in Kenya, policies about research funding priorities and ICT management have not promoted CS research capacity, and education reform has actually somewhat hindered CS capacity. Finally, interactions between universities, the private sector, and innovation hubs are also important. Our preliminary findings here indicate that there is perhaps a more centralized CS capacity being built in Uganda (centered around Makerere University), compared to Kenya where there is more of a distributed CS capacity in Nairobi, dispersed among multiple universities and innovation hubs. Our further research will explore how these different research ecosystems are related to socially and economically relevant innovation.

While our findings about CS research capacity are consistent with other studies and commentaries that argue that African scholars are more teaching-focused than Western academics, other studies have not indicated explicitly why this is so, or have implied that it is because of cultural differences between African countries and more developed countries, or by choice of the academics [11,12]. Our findings indicate that in addition to cultural differences and the capabilities and preferences of individual scholars, the relationship between teaching and research for CS academics is shaped by complex institutional and policy issues discussed above.

Previous studies have also emphasized how technical issues (such as bandwidth and computing capacity) are barriers to building local research capacity in Africa [11,12]. Our preliminary finding indicate that structural and institutional issues can also be significant roadblocks to building CS capacity and should be considered by other ICTD researchers working in this area.

We want to emphasize that these are preliminary findings. Beginning next year, we will conduct a structured survey with approximately 50 CS researchers and students in each of our two focus countries. We also aim to conduct about 80 in-depth interviews and follow a few key researchers via video ethnography. The surveys and interviews with donors, private sector representatives, and policy makers will allow us to track funding trends for CS, and participants' perceptions of change in funding over time. One issue that we are facing with our survey and interviews is how to measure productivity of researchers. Similar to Abrahams et al., our preliminary work shows that Kenyan and Ugandan CS researchers often publish in so-called

grey literature (working papers, reports) and not in peer-reviewed journals [1]. These kinds of outputs are harder to track via publication databases. We are experimenting with survey and interview questions to understand the impact of these types of outputs.

Interviews and ethnography will allow us to explore our second research objective that focuses on researcher motivations and identities. We are particularly interested in understanding how CS research in Kenya and Uganda may or may not be different from that in more developed countries.

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