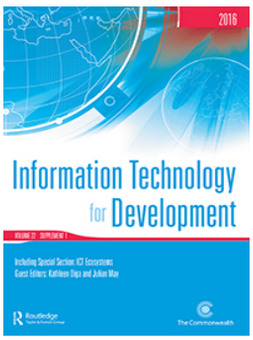

Information Technology for Development

ISSN: 0268-1102 (Print) 1554-0170 (Online) Journal homepage: https://www.tandfonline.com/loi/titd20

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To cite this article: Petronilla Muriithi, David Horner & Lyn Pemberton (2016) Factors contributing to adoption and use of information and communication technologies within research collaborations in Kenya, Information Technology for Development, 22:sup1, 84-100, DOI: 10.1080/02681102.2015.1121856

To link to this article: https://doi.org/10.1080/02681102.2015.1121856

Information Technology for Development, 2016
Vol. 22, Supplement 1, 84–100, http://dx.doi.org/10.1080/02681102.2015.1121856

Routledge
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Factors contributing to adoption and use of information and communication technologies within research collaborations in Kenya

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Use of information and communication technologies (ICTs) to support research work is becoming increasingly common. This study set out to establish how ICTs are being used to support collaborative research in Kenya, and identify factors within the ICT ecosystem that contribute to their adoption and use. A mixed methods research design, involving 248 academic scientists in 4 disciplines across 4 major Kenyan universities, was employed. We find little diversity in forms of ICTs used to support collaborative research within the studied population. Several factors affect adoption and use practices, including availability and access to ICT resources, nature of the work, national and institutional ICT and research environments and the social cultural practices of researchers. We explain our findings using Venkatesh et al.'s Unified Theory of Acceptance and Use of Technology model, which identifies four main constructs that affect adoption of technology such as performance expectancy, effort expectancy, facilitating conditions and social influence.

Keywords: knowledge production; research collaborations; developing countries; ICT adoption; UTAUT

1. Introduction

Collaboration in research has become an integral component of today's knowledge production process, and so has the use of information and communication technology (ICT) to support scientific work. Past research points to a number of positive impacts of ICT on research work. These include reduction in organizational and communication problems (Cummings & Kiesler, 2005; Walsh & Maloney, 2007), extension of networks (Gruzd, Staves, & Wilk, 2012; Ynalvez & Shrum, 2011), access to a wide range of information (Sooryamoorthy & Shrum, 2007) and increased productivity (Lee & Bozeman, 2005; Ynalvez & Shrum, 2011). However, despite their importance in scholarly communication, few studies address the concept of their use within the context of supporting research and scientific collaborations in developing countries.

How ICTs are adopted and used for research work depends on various factors within the use environment. Use has been found to vary across the various fields of science (Birnholtz, 2007; Walsh, Kucker, Maloney, & Gabbay, 2000). Some disciplines would greatly benefit from embedding ICT within their work activities, especially those whose tasks are more interdependent and pose more problems of coordination and communication (Olson & Olson, 2000; Walsh & Maloney, 2007). Use is also determined by supporting ICT infrastructure, including adequate internet connectivity (Duque et al., 2005; Ynalvez & Shrum, 2011) and institutional strategies in facilitating access and use (Kashorda & Waema, 2014). For individuals, personal ICT choices

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Sajda Qureshi is the accepting Editor in Chief for this article.

are influenced by perceived usefulness and ability of the technologies to meet researcher needs, and level of complexity in use (Davis, 1989; Kraut, Egido, & Galegher, 1988). The named factors form part of what the Open epolicy group (2005) refer to as the ICT ecosystem, as defined below:

> An ICT ecosystem encompasses the policies, strategies, processes, information, technologies, applications and stakeholders that together make up a technology environment for a country, government or an enterprise. Most importantly, an ICT ecosystem includes people – diverse individuals who create, buy, sell, regulate, manage and use technology. (p. 3)

Though a number of factors have been identified in literature as noted above, understanding the actual effects of ICT on collaborative work requires an assessment of their use within this context and for a particular research environment (Muriithi, 2013; Muriithi, Horner, & Pemberton, 2014). Using the Unified Theory of Acceptance and Use of Technology (UTAUT) model, developed by Venkatesh, Morris, Davis, and Davis (2003) as our analytical framework, we present the findings of a study aimed at understanding availability and use of ICTs to support collaborative research in Kenya, and factors within the ICT ecosystem that determine their adoption and use. Several models exist to explain user acceptance of technology and innovations. The UTAUT is a result of an analysis and integration of eight common technology acceptance and usage models, including the widely used Rogers (1995) Innovation Diffusion Theory and Davis (1989) Technology Acceptance Model (TAM). The model proposes four main factors influencing adoption and use of information technology such as performance expectancy, effort expectancy, social influence and facilitating conditions. This model was chosen because of its representation of a wider range of factors determining adoption and use of technology, not fully represented in the individual models.

2. Related literature

Past studies record a gradual increase in collaborative research over the years. Gibbons et al. (1994) attribute the increase to the emergence of a new mode of knowledge production that they refer to as Mode 2. They note that Mode 2 emphasizes the context of application, addressing challenging trans-disciplinary problems involving the interaction of many distributed actors. This is in contrast to Mode 1, which they point out as being mainly organized around disciplinary areas and highly institutionalized. The distributed nature of actors in Mode 2 make it "critically dependent upon the emerging computer and telecommunication technologies, and will favour those who can afford them" (Gibbons et al., 1994, p. 10). ICTs, therefore, play a major role in support for the Mode 2 kind of knowledge production status.

Socio-technical factors have been identified as playing a major role in determining adoption and use of ICT in various settings. In environments with constrained ICT resources, past studies show that support infrastructure play a significant role in decisions of which technology to use and sustained usage (Duque et al., 2005; Harle, 2009; Ynalvez & Shrum, 2011). The differences in use are demonstrated by Putman and Kolko (2010) in their analysis of internet use across two disparate regions, the USA and Central Asia. They found differences in internet connection speeds and integration into national systems affected the perceived usefulness of technologies, defining the use differences between the two regions. Like Putman and Kolko (2010), Kling, McKim, and King (2003) emphasize the need to look at communication systems as socio-technical interaction networks, allowing for analysis of user behavior and settings within which the technologies are used. Such kind of analysis is important in designing and organizing e forums that support scholarly communication, which, though influenced by technology, are largely defined by scientists' social structures and practices (Kling et al., 2003).

Many developing countries are characterized by poor ICT infrastructure, and low prioritization of the same (Harle, 2009). However, major developments in internet access have been realized within the last five years, as noted in the United Nations Millennium Development Goals (MDGs) reports of 2013 and 2014 (UN, 2013, 2014). Internet penetration in Africa doubled from 10% in 2010 to almost 20% in 2014, though constituting the lowest penetration of internet services globally (UN, 2014). Likewise, the ICT infrastructural situation in Kenya has improved to a large extent, especially after the arrival of the undersea cable at the Kenya coast in 2009. Major developments in the national ICT infrastructure have been realized, with major towns in the country now connected by fiber optic cabling (GoK, 2014). Changes have been realized in internet experience at the institutional level too. Before 2009, universities used to connect to the internet through satellites, which was very costly. For example, Kashorda and Waema (2014) report that in 2008, Kenya Education Network (KENET), the national research and education network in Kenya, was purchasing internet satellite bandwidth from Intelsat at a subsidized cost of $2300 per Mb/s per month. The high cost was being passed on to the Higher Education Institutions (HEIs); thus most institutions could not afford much bandwidth. Improved access to international bandwidth and improved national infrastructure has led to a reduction in internet bandwidth prices. KENET member institutions currently purchase bandwidth at $160 Mb/s, resulting in increased bandwidth consumption (Kashorda & Waema, 2014).

However, even with these major improvements, significant differences exist in ICT infrastructure between the developed and developing worlds (Ayanso, Cho, & Lertwachara, 2014; ITU, 2013), which determine how ICTs are used for research purposes. HEIs in the developed world enjoy high-capacity internet connections capable of supporting various forms of communication. In the UK, for instance, all research and education institutions are connected to each other and to the rest of the world through a super-fast Joint Academic Network, Janet, with speeds of up to 2 Tb/s and interconnect capacity of around 40 Gb/s (Janet, 2014). Kashorda and Muia (2013) report an interconnect capacity to KENET backbone of 1 Gb/s and above for 35 institutions in Kenya as of August 2013, though the bandwidth available to an institution depends on what an institution can afford to purchase. On the contrary, in the UK, the cost of internet access is shared among institutions, based on the wealth of an institution, as assessed by the Higher Education Funding Council. Thus no university is limited to the amount of bandwidth it can access based on "affordability" (Janet, 2014).

Moreover, the ICT environment may improve, but the effect on the work of scientists will depend on how the individuals make use of the technologies (Ynalvez & Shrum, 2011). This is affected by an interaction of a number of factors within the ICT and research ecosystem. As seen in Muriithi (2013), factors contributing to adoption and use of ICT for research work in Kenya are an area that has not been addressed adequately. Given the importance of ICT in supporting distributed collaborative work, this study sought to find the extent of diffusion of ICTs to support research collaborations in Kenya. However, it is important to note that the success of collaborations is not pinned on use of ICT alone. However, in this paper, we focus on issues related to ICT adoption and use, and their effects on collaborative research. The next section presents an outline of the sampling strategies and methods used in the survey.

3. Research method

The study employed a sequential explanatory mixed methods research design, involving use of both quantitative and qualitative forms of inquiry. A quantitative survey, in form of a questionnaire, was the primary data collection approach while the qualitative interviews played the "support role." The data collection exercise took place between October 2011 and May 2012.

3.1. *The sample*

Four disciplines, agriculture, engineering, public health and computing, and four institutions were sampled for the survey. The Field of Science (FoS) classification in the *Frascati Manual* (OECD, 2007) was adapted for selection of the disciplines, to reflect diversities in various disciplinary areas. At least one discipline under each of the major fields of classification was included, with the exception of humanities. A study of literature shows that predominantly theoretical fields, as is the case with most disciplines classified under humanities, have less collaborative activity (Birnholtz, 2007; Melin, 2000). This was confirmed by a desk-based survey of disciplines in the humanities that involved retrieval of publication records of individual researchers from CVs uploaded on the university websites, within the selected Kenyan universities. The desk-based survey revealed less coauthored publications in the humanities (coauthorship is a commonly used measure of collaboration). Since this research mainly relates to issues of collaborative research, and for the purpose of selecting a sample that was manageable within the cost and time limits, a decision was made to exclude humanities. Selection within the broader fields was based on significance of research to the country, nature of the discipline and accessibility of the data and participants. For example, it was suspected that getting information from some specialist areas within the medical sciences would be problematic due to the confidential nature of the work.

The universities sampled for the study were identified through the preliminary desk-based survey of university websites, which sought to find out the level of establishment of the selected disciplines within each institution. Practical constraints within each selection, in terms of the size of the target population, were considered in coming up with the final selection. The quantitative survey targeted all academic members of staff within the selected disciplines and universities. The desk-based survey led to identification of academic members of staff affiliated to the departments within each disciplinary area under study, yielding an initial estimate of 450 researchers as the approximate size of the target population. Further sampling was found unnecessary due to the need for an intensive focus on the academic research community to understand in detail their ICT-related collaboration practices.

The quantitative survey was backed up by qualitative interviews with 15 individuals selected across the sample. For a balanced representation across disciplines and institutions, the selection was based on the disciplinary area and institutional affiliation, and level of involvement in research collaborations. The qualitative interviews led to a deeper understanding of issues that stood out in relation to use of ICTs in supporting collaborative research, based on personal experiences of researchers. They also provided for an exploration of upcoming issues that had not been included in the quantitative survey.

3.2. *Data and analysis*

The quantitative survey included measures of availability of ICT resources, frequency of use of the internet and type of ICT used for the various collaborative activities. To aid in understanding of factors contributing to adoption and use, there were measures of the level of skills in use of ICT and an assessment of major problems in use of the internet. To gain an insight into the importance of ICT in supporting collaborative research among this population, the effects of ICT on collaboration and productivity were also assessed. Self-reported measures of collaboration and productivity were employed. Collaboration was measured by the number of collaborative research projects researchers were involved in, both national and international, over the last 10 years. Productivity was measured by the number of publications within the same period.

Data derived from the questionnaire-based survey were analyzed, using statistical analysis software, IBM SPSS Statistics Version 20. Descriptive statistics provided general profiles of the

respondents and basic indicators for research work environments, productivity and ICT availability and use. Cross tabulation and Chi-square tests of association were used to analyze relationships between the various variables. This led to an understanding of how the various factors including disciplinary area and nature of area of specialization, level of academic qualification, region of study, gender and level of involvement in collaborative work interacted to influence use of ICT to support collaborative work. Correlation tests were used to assess the relationship between use of ICT and collaboration and productivity levels, and their role in reducing collaboration problems. A qualitative data analysis software QSR NVivo 8 was used to help organize and sort the data within and across participant interviews, guided by the broader themes under investigation in the quantitative survey. The two sets of data (qualitative and quantitative) were synthesized at analysis.

The results discussed are part of a wider study, investigating the collaboration process within the scientific academic research community in Kenya and the factors shaping it. We start by presenting statistics on usage, followed by an analysis of the factors contributing to adoption and use.

4. Findings and discussion

4.1. *General description of respondents*

The study yielded a 55.1% response rate (a total of 248 responses out of the estimated 450). Of the total responses, 41.5% were from JKUAT, University of Nairobi (UON) 31.1%, Moi University (MU) 16.9% and Kenyatta University (KU) 10.5%. Of the four disciplines sampled, 49.4% of the respondents were from engineering, 27.5% from agriculture, 13.0% from public health and (10.1%) from computing. Table 1 shows a summary of basic demographic, research work involvement and ICT support indicators for the participants.

Table 1. Summary of basic descriptive statistics of respondents.

Variable	*N*	Mean	Modeob
Personal characteristics			
Age (25–30 = 1; 31–40 = 2; 41–50 = 3; 51–60 = 4; over 60 = 5)	228	2.96	3
Gender (1 = Male, 0 = Female)	247	.79	1
Educational background			
Has a Ph.D. (1 = Yes, 0 = No)	225	.55	1
Where trained (Africa = 1, Developed country = 0)	211	.48	0
Scientific collaboration and productivity			
Involvement in collaboration (1 = Yes, 0 = No)	248	.65	1
Current projects	149	1.80	1
Past projects (in 10 years)	145	2.43	2
Publications in the last 10 years	221	7.46	10
ICT availability and use			
Computer/laptop in work place (1 = Yes, 0 = No)	248	.81	1
Computer/laptop at home (1 = Yes, 0 = No)	248	.85	1
Internet connection at work place (1 = Yes, 0 = No)	248	.87	1
Internet connection at home (1 = Yes, 0 = No)	248	.51	1
Mobile phone (1 = Yes, 0 = No)	248	.89	1
Internet on mobile phone (1 = Yes, 0 = No)	248	.55	1
Level of skills (1 = sophisticated, 2 = more than basic but not sophisticated, 3 = basic, 4 = do not use computers	235	1.94	2
Frequency of use of the internet in hours (1 = 0–5, 2 = 6–10, 3 = 11–20, 4 = over 20, 5 = not at all)	235	2.22	1

The 41–50 age bracket constituted 30.7% of the respondents, 28.9% in the 31–40, 25.4% in the 51–60 and 7.5% in the 25–30 and over 60 age bracket categories. Males were 79% of the total respondents, 55% of the respondents had a Ph.D. and 65% were involved in collaborative research projects. A majority (58.3%) of the respondents indicated having more than the basic skills but not sophisticated in use of computers, while 24.3% saw themselves as sophisticated users. Only 0.4% did not use computers.

4.2. *Availability and use of ICT*

The quantitative results indicated that majority of respondents had access to basic ICT resources, with over 80% having access to a computer or laptop at work or at home, mobile phone and internet connection at the work place (see Table 1). However, it is important to note that simple access may not translate to ready access at any one time one needs to use the resource. Respondents reported sharing of computers in their offices and constant internet down times, which does not translate to ready access. A number of respondents have invested in "self-infrastructure," as seen in the high percentage of those with computer/laptop at home, though fewer indicated having means of connecting to the internet at home (51%) or internet access on a mobile phone (55%). Investment in self-infrastructure was seen as a response to unreliable computing facilities at the university, and a bid to increase flexibility in work processes and access to information. However, this comes with additional cost implications, especially as concerns internet access which was mainly in the form of privately owned broadband modems.

As seen in Muriithi (2013) and Muriithi et al. (2014), the results as presented in Table 2 show that email is the most commonly used form of communication among academics for all the activities listed, followed by phone and face-to-face meetings. Voice over internet protocol (VOIP) applications, web forums, chat and fax are less common. Their low usage was attributed to factors such as poor internet connectivity and lack of awareness of some of the technologies. While email use is sufficient for some forms of communication such as simple exchange of ideas, Kraut et al. (1988) observe that other forms of communication means would be better suited to support intensive kinds of interaction and exchange. VOIP applications such as Skype emulate face-to-face meetings better, and would be more suitable for activities which

Table 2. Percentage use of communication technologies for various activities in collaborations.

Activity	Email	Phone	VOIP	Web forum	Chat	Fax	Face to face	Other
Contacting members within locality	88.4	87.8	3.7	2.4	7.3	0.0	64	0.6
Contacting members outside locality	97.6	63.0	12.7	4.2	9.7	1.2	9.7	0.6
Planning activities within locality	86.3	72.7	3.7	1.9	3.1	0.6	59.6	1.9
Planning project activities remotely	92.5	59.4	11.2	5.6	6.2	0.0	10.0	1.2
Monitoring progress	85.7	72.0	6.8	3.7	4.3	0.6	49.1	1.9
Soliciting input for a decision	88.8	69.6	6.2	5.0	4.3	1.9	46.0	0.0
Giving updates on progress	93.8	60.2	7.5	5.0	4.3	1.2	48.4	2.5
Sharing documents and information	96.9	32.3	5.6	5.0	2.5	3.7	36.6	5.6
Communicating results	95.7	38.5	4.3	5.0	5.0	2.5	50.9	8.1
Average percentage of use	92	62	7	4	5	1	42	2

are considered most appropriately communicated by face-to-face interactions. However, they scored extremely low in this survey.

Taking email, the most commonly used communication technology, a Chi-square test of association of email use against some categories indicated significant differences in usage across disciplinary areas, area of specialization, level of academic qualification, region of graduate studies and gender. Agriculturalists had the highest likelihood of using email at 77.9% and, surprisingly, computer scientists had the lowest at 52%. Significant differences were also seen between those who indicated their area of specialization as experimental (78.6%) and applied (74.1%), as opposed to theoretical (54.7%). Those with a Ph.D. were more likely to use email for communication (83.1%) as compared to those without (51.1%). Those who studied in a developed country were more likely to use email (75.2%), than those who studied in Africa (59.9%). Males were more likely to use email (69.6%) than were females (49.1%). The differences in use were non-significant across age groups and academic institutions, unlike studies that have found use of the internet to be more associated with younger persons (Gomez, 2014; Waema & Miroro, 2014). A Spearman Rank correlation between email use and both corroboration and productivity levels show that use of email is significantly correlated with both increase in collaboration ($r = .196$, $p < .05$) and productivity ($r = .365$, $p < .001$). This could be an indication of the importance of ICT in supporting collaboration processes. The next section presents a discussion on factors accounting for the differences as well as general levels in adoption and use, using UTAUT as the analytical framework.

4.3. *ICT adoption and use factors*

Venkatesh et al. (2003), in their model the UTAUT, propose four main factors that influence the intention to use and usage of information technology as performance expectancy, effort expectancy, social influence and facilitating conditions. The following subsections represent an analysis of the findings and their discussion in reference to the constructs represented in UTAUT.

4.3.1. *Performance expectancy*

Performance expectancy is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003, p. 447). This can be looked at as "perceived usefulness" of the technology in Davis' (1989) TAM model. In this study, performance expectancy was found to be influenced by personal and socio-cultural factors, including perceived benefits and existing research cultures and practices as well as demographic factors.

Perceived benefits: A technology that is perceived as aiding better performance of tasks while offering cost benefits (cost can also be in the form of time) is expected to have a higher rate of adoption (Venkatesh et al., 2003). The quantitative results indicate that use of email is significantly correlated with both increase in collaboration and productivity. As seen in Muriithi (2013) and Muriithi et al. (2014), a factor analysis carried out on common problems[1] in collaborations identified from literature extracted three problem dimensions: problems of socio-cultural nature; problems of management and control and problems of availability of resources. A correlation of the factor scores produced and frequency of use of the internet was significant for problems related to management and control and frequency of using the internet ($r = .231$, $p < .01$). This is an indication that frequent use of the internet significantly reduces problems of management and control, consistent with Walsh and Maloney (2007). This benefit for collaborative work is likely to have a positive effect on perceived usefulness, leading to higher rates of adoption and use.

The perceived benefits could to some extent influence the attitude and enthusiasm to explore and embrace ICTs for collaborative work. Some participants felt that ICTs were inappropriate for the kind of work they were involved in, as pointed out by an engineer who felt that "Some of the things are really difficult because there are things you have to explain on paper and drawing and so on. Really you need to be there and discuss." This probably points to three issues: a lack of appreciation of the power of ICTs in supporting a diverse range of activities, or a lack of knowledge of diverse technologies that could support the activities referred to as best performed by face-to-face meetings, or a culture defined by embracing traditional ways of doing things and a resistance to change. On the other hand, others felt the kind of communication they engage in had not called for use of "sophisticated technologies." This could be a reflection of the complexity with which some forms of ICT are viewed, with the majority preferring to use what they saw as less complex, email and mobile phone. However, this can also be seen as an indication that the level and type of required technological support differs between projects and disciplines, determined by the level and type of interaction.

Culture of use: Varying rates of adoption and use could also be as result of a lack of exposure to a culture of ICT usage. Participants complained that most communication and documentation in the university was still in hard copy form, a reflection of university systems that were still entrenched in manual systems and operations. In the search for information on collaborative research projects during the data collection exercise for this study, the researcher was often required to extract information from piles of paper work. This can be seen to support Kashorda and Waema's (2014) finding, that universities were "still not ready to use ICT to transform learning and research" (p. 36). A culture of not using computing facilities in search of information, or to support their learning from the earlier education life, and a culture of not using ICT for the wider university processes, could affect the morale and exploration of newer forms of ICT that could be beneficial to collaborative work. This culture of use is reflected by those who have studied in developed countries, where use of communication technologies is ubiquitous, and reflects higher rates of usage in this study.

Demographic factors: More usage was recorded by those with Ph.D. level of academic qualification. This could be attributed to the higher levels of collaboration recorded in this category (74% of those with Ph.D. were involved in collaborative research as compared to 26% of those without). These individuals may display an increased reliance on ICT to support their collaborative work, and thus a positive effect on perceived usefulness. The results of this study also reflect higher rates of adoption and use among men as compared to women. Muinde (2009) attributes this to a cultural setup that encourages boys/men to take up the tougher scientific courses including computing, reflected in the higher ratio of male to female students in the science-based subjects. Males also dominate academic staffing levels in the sciences. For example, in the computing department of one of the sampled universities, only 4 out of a total of 25 academic members of staff are female. The mentality that trying out the more complex technologies is more of a "man affair" may affect adoption and use between the genders.

4.3.2. *Effort expectancy*

Effort expectancy is defined as "the degree of ease associated with the use of the system" (Venkatesh et al., 2003, p. 450), similar to Davis' (1989) "Perceived Ease of Use" in the TAM model. This includes complexities in learning and interacting with the system, and the time and effort required to perform a task. Technologies that are perceived as complex and difficult to use will have a slow rate of adoption.

Results from the quantitative survey show those who indicated having the above basic skills in use of computers are more frequent users of the internet. More knowledge and skills could

mean less effort in using various technologies, making them better adopters. Unlike Muinde (2009) who reports many in academia in Kenya lack computer literacy, over 80% of the respondents indicated they are above the basic level of skills in using computers. This could be a result of the efforts of many of the universities in providing basic computer literacy skills to their members of staff. However, participants reported lack of specialized training for applications tailored for performing specific tasks. This, in the eyes of one participant, makes gaining the skills an expensive venture, and can be non-motivating and contribute to lower rates of adoption for the particular technologies.

> There is also the challenge of the requisite skills and skills upgrading . . . for example if you want to use SPSS statistics to analyse your data, first of all you don't have the money to get the license or a copy of the software. Secondly, , you don't have the skills necessary to help you be able to use that package and those skills furthermore don't come easy so you have to pay for them.

Results of this study show that some of the participants believe computing systems are complex, which may affect the intention to use ICTs. Participants complained of poorly designed information sources such as university websites, which lack content or present complexities in searching for content, and library information systems (LIS) that present problems in accessing materials remotely and from mobile devices. These issues present complexities in use. LIS have been introduced rather recently in some universities (e.g. in one of the sampled universities, an LIS was only rolled out in October 2012), and can be said to be going through some teething problems, with the situation of access to materials expected to improve with time. However, this is dependent on the commitment of a number of actors in the ICT ecosystem involved in making it happen, including the policy-makers who decide on access policies, and ICT departments that organize the technical implementation.

The importance of ICTs meeting local needs for them to be useful to the communities they serve is stressed in Unwin (2009) and Gomez (2014). Proper design of systems that meet researcher needs, are compatible with existing research practices and present less complexities in learning and use would encourage uptake and use. A number of respondents pointed to the need for research information systems (RIS), at the national level that were lacking:

> The NCST should be able to tell the scientific community, who is doing what and where they are, so that people can know where to go hunting for collaborators. Similarly, the universities should also be able to do the same, say we have this discipline, these people are working in this area, as a way of getting the information around, of who is doing what and where they are and what they are working on, so that people can look them up.

Through RIS, researchers could keep informed on ongoing and past research, identify individuals with similar research interests, seek connections and encourage sharing of information. A system offering such services is likely to be received positively, as it would be addressing a prevalent problem within the Kenyan research community.

4.3.3. *Facilitating conditions*

The facilitating conditions construct is defined as "the degree to which an individual believes that organisational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p. 453). Items discussed under this construct include the existing ICT infrastructure, availability of knowledge and skills necessary to use ICTs, compatibility with other systems used and work style, and technical support and the role of the university in facilitating adoption and use, all part of the elements that form an ICT ecosystem.

Availability of ICT resources: Use of computing technologies is highly dependent on supporting infrastructure. Though a majority of respondents have basic tools for communication, "digital poverty" as described in May, Waema, and Bjåstad (2014), with reference to access

to ICTs, awareness of their usefulness and possessing relevant skills to make meaningful use of a range of them is prevalent in Kenyan universities. Use of the internet brings a number of challenges. The dimension of problems in use of the internet shows that sites and materials that require payment for use and internet downtime led to problems of using the internet as indicated by over 75% of the respondents, reflecting issues in availability of and access to digital resources. Consistent with past studies in the region, (Duque et al., 2005; Harle, 2009; Kashorda & Waema, 2009), lack of reliable internet connectivity was cited widely in the qualitative survey as a major stumbling block to use of internet-mediated technologies for collaborative work. One participant had been appointed to head a newly established department whose offices did not have cabled or wireless internet connectivity, expressing his frustration at the situation:

> We are still struggling with internet access here. Clearly the kind or work that we do . . . it's difficult without steady stable internet connectivity. You have to dash to a cyber cafe from time to time. You have got to cough lots of money to buy data bundles from the service providers.

It is therefore not unusual to find academic members of staff/researchers in public access computing venues, which Gomez (2014) notes have become common in developing countries and are favored due to good customer service and connection speed. A number of participants indicated that to deal with the unreliable internet connectivity at the university, they resorted to using privately owned mobile broadband modems, which can be quite costly. Problems in internet access affected use of a diverse range of technologies. One participant remarked that he had given up on using Skype because he had to wait for off-peak hours of internet traffic (i.e. early morning or late in the evening). Even with the off-peak hours, he could not be assured of a smooth conversation as the connectivity is usually poor. Some complained of expensive software which they had to acquire privately to support their work as the university could only provide the most commonly used software across the departments.

Although internet access problems have been identified in past studies, the extent to which they are a problem in Kenyan universities is quite surprising, given the high rating of Kenya as seen in ITU (2013), as one of the leaders in bridging the digital divide in the region. The national ICT Master Plan of 2014 notes major developments in ICT environment in the country in the last five years, including "rollout of the National Optic Fiber Backbone Infrastructure and four undersea cables, implementation of high-speed networks by telecommunications operators, establishment of policy frameworks and regulation of the ICT sector" (GoK, 2014, p. 3), among others. It would be expected that such improvements have a major impact on internet connectivity in HEIs in Kenya, among other sectors. Though there has been a considerable increase in bandwidth consumption in Kenyan universities (see Section 2), Kashorda and Waema (2014) note that a huge increase in student enrollment, thus increased demand for internet services, not matched by increase in the budget toward internet bandwidth has seen problems of internet connectivity in Kenyan universities persist. According to Kashorda and Waema (2014), the majority of universities assign only 0.5% of their operational budgets toward the cost of internet bandwidth, way below the 10% recommended in the 10th Cycle of Performance Contracting for tertiary institutions, under which public universities fall. To embrace technology, the need to prioritize improvement in ICT infrastructure was emphasized in this study. However, Ynalvez and Shrum (2011) note that the effect on the work of scientists will depend on how the individuals make use of the technologies.

Availability of Technical support: The importance of availability of technical support in use of ICT, closely associated with mediating the effects of effort expectancy has been noted as affecting usage behavior (Venkatesh et al., 2003). Users tend to gain more confidence in use of technology if they know that help, if needed, will be available. However, a number of

respondents complained of poor technical support and unreliable services, as evidenced in the frequent internet downtimes and the length of time it took to get a problem sorted out:

> . . . the problem is the maintenance . . . in the university, the user numbers are very high, everybody is into the internet, so you can imagine the demands on the equipment. You see the ideal situation – because I have worked with some international organisations who have very stable systems – is to have a dedicated team for ICT for example, the moment you complain, they are there to sort it out. These are really experts of the internet and other communication solutions. That however lacks in public institutions.

The unreliable nature of university email systems was pointed out, in terms of availability of the service and limitations in mailbox storage, which perhaps accounted for the large number of respondents who, it was noted in the process of carrying out the online survey, used commercial email addresses. These problems, coupled with frequent power outages, which, consistent with Kweku (2012), were noted as relatively common, could affect the use of and motivation to use digital systems and online content. Universities therefore have a role to play in providing qualified, reliable and adequate technical support, guided by policies regarding the qualifications, number and work definition of the required technical support team.

Lack of awareness of a diverse range of technologies: A number of participants cited lack of awareness of available ICT options, noted by Rogers (2003) as affecting adoption of innovations. This is quite surprising for a group of people seen as part of the most educated and elite in the community. For people to make use of the technologies, they have to be aware of them. The communication channels used to create awareness of an innovation could determine the rate of adoption (Rogers, 2003). Rogers notes that while use of mass media is associated with faster rate of adoption, interpersonal channels would be more useful for complex technologies. Some participants in the study indicated having had to adjust to communication modes used by their collaborators and networks, in support of Rogers' view. However, participants called for universities to take a more active role in facilitating awareness of the various technologies, as well as supporting researchers in acquiring the necessary skills through organized training in the use of such technologies, to instill confidence in their use.

Institutional policies: The factors discussed under this section show that universities have a big role to play in facilitating adoption and use of ICT, not only for supporting research work but also for the entire university processes. Muinde (2009) and Kashorda and Waema (2014) note that the university leadership to a large extent determines the ICT environment. Having adequate ICT policies and regulatory frameworks is important, so is their implementation. Out of the four universities involved in the study, only two had ICT policy documents at the time of data collection to guide implementation and use of ICT facilities and services. But even so, participants complained of lack of implementation of policy, and thus a disconnect between what is on paper and the real situation on the ground. The disparities, for instance as noted by some participants, are seen in the proposed standards regarding improved connectivity and reliability of networks and services, and meeting of training needs.

Participants also cited a poor research culture in universities in Kenya, with much focus on teaching as opposed to research, mainly attributed to funding issues. Financial records from two of the sampled universities show that the government funding to public universities constitutes only 30% of the universities' operational budgets. Universities are expected to meet the huge budget deficits through funds generated internally, and barely have funds to commit to research. The need to raise the much needed funds to sustain universities has resulted in an influx of academic programs and large student intake that is not proportional to academic staff numbers. This has led to researchers having to deal with heavy teaching loads with many complaining of no time for research, contributing to the poor research culture.

Institutions play a major role in creating and facilitating an enabling research environment. Disparities exist in research support systems across universities, such as in existing policies, meeting of research skills training needs and information availability as reflected in content on university websites and digital repositories. However, a number of issues such as resource availability (including funding, ICT resources and time) emerged salient across the general Kenyan research community, an indication that the majority of researchers face similar problems within their research and ICT ecosystems.

4.3.4. *Social influence*

Social influence is defined as "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003, p. 451). This construct is represented by items referring to influence from important individuals in the surrounding environment and support systems. The social system and communication practices of those a researcher mainly engages with can influence the mode of communication adopted. A number of respondents gave the reasons for their extensive use of email as that it is the kind of technology most people are familiar with and use. One participant noted that he resorted to using Skype because it was the most convenient form of meeting with his collaborators based in different parts of the world. The individual had to adapt to what the others in his circle mainly used, so as to comfortably identify himself with the group and participate in discussions. The established differences in use of internet technologies between those who studied in developed countries and those who studied in developing countries could partly be a result of the social influence of technology use within the environments in which they studied.

Venkatesh and Davis (2000) argue that social influence constructs are mainly significant when use is mandatory, and individuals have to comply in response to social pressure. However, choice of technology use for research collaboration is not a mandatory requirement, and tends to be dependent on individual researchers and teams' preferences. Perhaps making use of ICT a mandatory requirement for some university processes would encourage formation of a digital community whose effects would diffuse into collaborative research practices.

4.3.5. *Disciplinary area (as an additional construct in UTAUT)*

This section has identified factors contributing to adoption and use of ICT within research collaboration, packaged within the UTAUT framework. In addition to the constructs discussed above, the study also found significant differences in use across disciplinary areas. Some disciplines are associated with higher levels of dependence for both skills and resources to get work done, reflecting higher demand for collaborative work (Birnholtz, 2007; Olson & Olson, 2000). Such disciplines may reflect more reliance on use of ICT to support collaborative activities. Agriculturalists recorded highest level of adoption and usage of ICT in comparison to engineering, public health and computing. Majority of agriculturalists exhibited a culture of solving problems together, as exemplified by a participant who felt that an individual or single department may not have the expertise, capability and capacity to address a problem:

> In our work on iron and zinc concentration, one of the big questions was how effective the human body is in extracting the nutrients from the beans. We can produce the grain, but some other people need to monitor, what happens to that grain when it gets into the human body, so we had to collaborate with KEMRI, in Kenyatta hospital, because they are the ones who have the expertise of feeding and taking blood samples and that kind of thing to track the uptake of the nutrients . . . if we are analysing bean samples, we can only do maybe, probably our capacities maybe 2000 or 3000 samples a year, but sometimes we have more than 10000 samples to do, so you need people with automated

> systems which are very expensive, in that case we can work with people in other countries – to send samples to them to analyse, and they give you their response.

A number of participants from agriculture also indicated they belonged to various national and international disciplinary networks solving particular issues within the wider agricultural field. On the other hand, a participant had this to say about computing:

> Computing research is still not very well structured. Even research areas sometimes are still not very well structured, like for example, some of the things I am doing, simulations and thermo-smart systems, it's very hard to tell you who else is doing that around here so that I collaborate with him or her. So it's still not very well structured since this is an area that is fairly green in this part of the world . . . .

Agriculture is well established as a discipline in the majority of major Kenyan public universities, and seems to attract more funding both locally and internationally, perhaps due to its role in national development. Subsequently, it reflects higher levels of collaborative activity as compared to other disciplines. The need to support increased interactions, activities and resulting networks, which apparently differ across disciplines, would account for disparities in levels of ICT adoption and use.

Figure 1 presents a summary of factors influencing adoption and use of ICT within research collaborations in Kenya, contextualized within the constructs represented by UTAUT. As can be seen in Figure 1, the facilitating conditions construct has a major influence on all the other constructs, corroborating Venkatesh et al.'s (2003) findings on their effects on both beliefs and

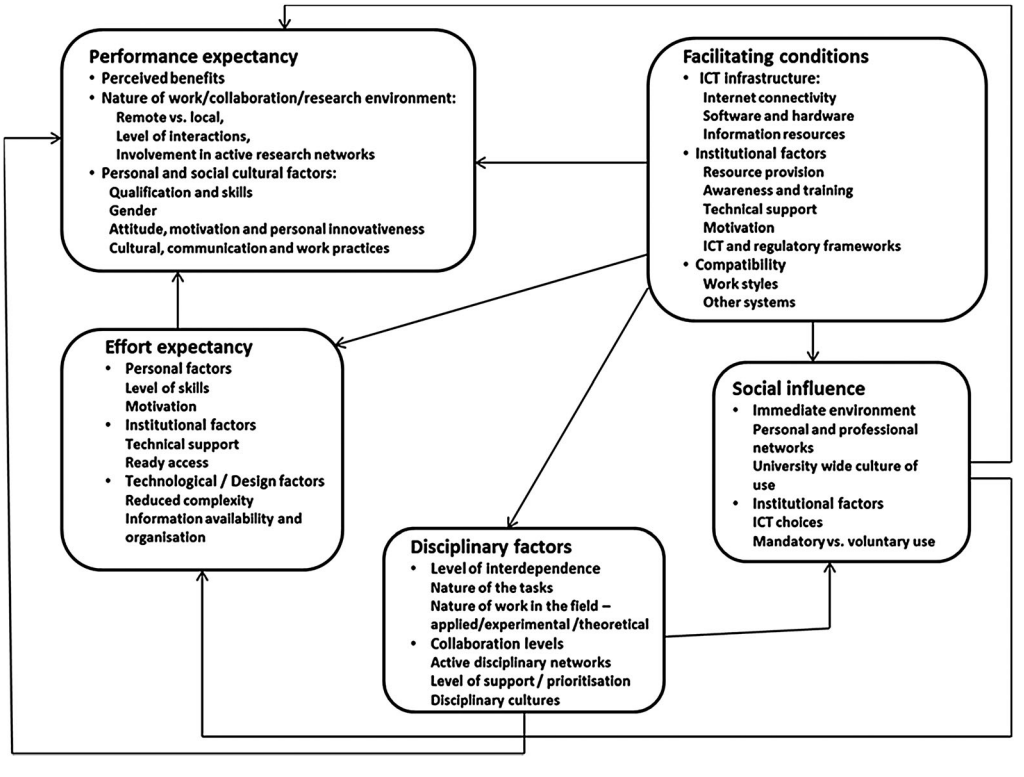

Figure 1. A model of factors affecting adoption and use of ICT within research collaborations in Kenya.

actual usage of technology. Difficulties in accessing and using various forms of ICT, mainly defined by institutional ICT environments, affect both performance and effort expectancy, while facilitating use paves way for the effects of social influence, as more individuals tend to adopt the ICTs based on culture of usage within the immediate environment. Institutional and national support structures that tend to prioritize research in certain fields in turn affect collaboration levels within a discipline and corresponding need for ICT support.

Performance expectancy, mostly defined by personal and socio-cultural beliefs and practices, is affected by the majority of items represented in the other constructs. For example: the complexity (effort expectancy) associated with use of some technologies lowers the motivation and attitude toward their use; the social influence of communication modes within the immediate environment, and nature of the work (disciplinary factors) influence the perceived usefulness.

Past studies show that many countries in Africa are characterized by similar contextual situations (Harle, 2009; Mouton, 2008). The model could be used as a guide to similar investigations in the region and wider developing world context to produce country-specific information.

5. Conclusions

This paper sought to establish how ICTs are being used to support research collaborations in Kenya, and factors that influence levels of adoption and use. It is apparent that people will use technology based on how it works for them, especially its effectiveness in performance of tasks and achievement of their communication goals. This study shows that researchers hardly make use of the range of ICTs available to support collaborative activities, the most commonly used being email and phone. A number of factors within the ICT ecosystem are identified as affecting adoption and use. These include: the researchers themselves, in terms of their perception toward the usefulness of ICT for their work. This perception is affected by other factors within the ecosystem such as availability and access to the ICTs and their ability to meet researcher needs, cultural practices in researchers' work environments and the capacity of the researcher to make use of various technologies as defined by the level of skills. The institutions play a major role in defining the ICT and research environments under which researchers operate. They determine availability and access to ICT resources, creation of awareness of various technologies, building skills and providing for reliable technical support and motivation of researchers to engage in more research.

The factors established as influencing level of adoption and use are discussed within the UTAUT framework. Performance expectancy and facilitating conditions seem to have most influence on adoption of ICTs for collaborative research. In addition to the four constructs represented in UTAUT, disciplinary factors, mostly defined by the nature of the work and levels of collaborative activity associated with a discipline, were found to have significant effects on levels of adoption and use of ICT. Studies using UTAUT to analyze adoption of ICT for knowledge production processes could consider disciplinary or specialist area as an extra construct that would be significant in determining adoption and use.

The analytical framework indicates that the various elements of the ICT and research ecosystem need to work together for benefits of ICT to research collaborations to be realized. Researchers need to appreciate the benefits and effects of ICT on their research work, and thus put more effort into integrating them into their work practices. The university management plays a major role in creating an enabling environment. It should be noted that the focus on ICT in this paper should not be construed to mean success in collaborations is all about ICT use. Several other factors interact to contribute to successful collaborations. A discussion of these factors is beyond the scope of this paper.

Note

1. Listed problem areas were availability and access to special equipment, ease of getting funding, amount of funding, administration of the funding, availability of skilled personnel, defining roles, coordination of members' activities, timely delivery of results, diverse disciplinary training of collaborators, cultural differences, resolving conflicts, scientific competition, information security, authorship inclusion and order, selection of a publication forum, leadership and control, availability of time to commit to research.

Disclosure statement

No potential conflict of interest was reported by the authors.

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