**Asian Journal of Contemporary Education**
*DOI: 10.18488/journal.137.2018.21.43.52*
*Vol. 2, No. 1, 43-52*

*URL: www.aessweb.com*

# TECHNOLOGY RESOURCES FOR TEACHING SECONDARY MATHEMATICS: LESSONS FROM EARLY AND LATE ADOPTERS OF TECHNOLOGY IN KENYA

**Leonard M. Kamau**[1]
**Jonathan Mwania**[2+]
**Antony K. Njue**[3]

[1,3]*Department of Educational Communication and Technology, South Eastern Kenya University, Kenya*
[2]*Department of Educational Psychology, South Eastern Kenya University, Kenya*
*Email: muemamwania@yahoo.com*

*(+ Corresponding author)*

**Article History**
Received: 25 May 2018
Revised: 19 June 2018
Accepted: 24 June 2018
Published: 13 April 2018

**Keywords**
Technology
Diffusion of innovation
Theory
Early adopters
Late adopters
Teachers
Mathematics
Kenya.

## ABSTRACT

This study investigated the extent to which access to technology resources influenced their adoption by mathematics teachers in their teaching. The study conducted in Nairobi County in the summer of 2013 applied Rogers' diffusion of innovation theory. Participants were categorized either as early or later adopters of technology based on availability of technology or whether or not they had adopted technology for instructional purposes at their schools. Six teachers were selected; three in each category for interviews and classroom observations. The findings revealed that early adoption of technology was associated with the teachers (early adopters) belief that technology would benefit them and their students. Late adopters on their part tended to believe that technology was not compatible with their instructional needs. Interestingly, both categories of adopters agreed that technology was complex to use for instructional purposes pointing towards lack of adequate training. Similarly, both groups considered computer department in their schools a hindrance to technology adoption. Findings also highlighted the scarcity of technology resources which impacted negatively on the process of adoption. These findings suggest that teachers be trained adequately and role of the computer department as the custodian of technology at schools be liberalized. Additionally, stakeholders are advised to consider installing technology resources in classes to encourage their use rather than locking them in laboratories.

**Contribution/ Originality**: This study documents the primary role played by resources for teaching secondary mathematics and lessons from early and late adopters of technology in Kenya. The study makes suggests that schools develop technology plans to facilitate effective technology adoption, school managers leading in formulating the plans based on research and successful models.

## 1. INTRODUCTION

The evolution of technology has the potential for transforming teaching and learning in schools. Hew and Brush (2007) observed that since the "birth of the motion picture in 1922 to the advent of the computer in the mid-1970s educators have been intrigued with the potential of technology to help transform education and improve student learning" (p. 224). As a result of the benefits associated with technology use in education, "both developed and developing countries are bringing about educational reforms, with a clear focus on [technology] integration in education" (Jhurreev, 2005).

Kenya is one such country that has made considerable strides to introduce technology in education to support teaching and learning in various levels of education, basic level (primary and secondary) of education included. Realizing the importance of technology in education and buoyed by prosperity goals of the Kenya Vision 2030, the Government of Kenya (GoK) in 2006 through the Ministry of Information, Communication and Technology, developed the National ICT Policy that sought to "facilitate sustained economic growth and poverty reduction, promote social justice and equity, mainstream gender in national development; empower the youth and disadvantaged groups, stimulate investment and innovation in [technology], and achieve universal access to [technology]" (Republic of Kenya, 2006). In this policy, one of the objectives related to technology in education emphasized is "encouraging the use of [technology] in schools, colleges, universities and other educational institutions in the country so as to improve the quality of teaching and learning" (RoK, 2006). In particular, the policy projected that an improved learning of mathematics and sciences would enable the country realizes some of the goals anchored in the Kenya Vision 2030 blue print. It is professed that technology adoption in the education system would contribute to improved students' achievement in mathematics and sciences in several ways. These among others include teacher training, reducing high student-teacher ratios, supplementing existing instructional resources, access of online teaching and learning materials, and improvement of classroom practice (Wima and Lawler, 2007).

Empirical evidence associate several factors with adoption of technology in teaching and learning of mathematics. These include access to technology infrastructure, school support as well as technical support. Documentary evidence show that lack of hardware and software is one of the greatest obstacles to technology adoption in schools in many developing countries. In Turkey, for example, Akbaba-Altun (2006) examined issues related to integrating computer technologies into a centralized education system. Data were collected from 17 school principals, 15 computer coordinators, and 150 elementary education supervisors through a survey and semi-structured interviews revealed that limited technology resources and infrastructure as well as incompetent personnel were the main variables inhibiting technology adoption in the classrooms. Akbaba-Altun recommended that policymakers should develop and implement a comprehensive technology vision and mission in order to reduce the challenges of technology implementation at the school level and throughout the country.

School support is also considered a factor that influences teachers' effective adoption of technology in the classroom (Wanjala *et al*., 2011). Demiraslan and Usluel (2008) examined issues in the technology adoption process at the classroom level with a group of Turkish primary school teachers, students, and technology coordinators. They observed 15 lessons with the aim of establishing the extent of technology availability and use; the type of lesson activities; how students were grouped in the technology classroom, the learning content, the role of the teacher, and the innovative uses of technology in the classroom. Data analysis revealed that administrations in some schools did not provide opportunities for teachers' professional development; lacked coordinated regulation of technology integration; and students did not have access to technology tools. These findings suggested that school leadership plays a significant role in the implementation of technology adoption in schools. At the same time, technical support for teachers is also important when new technological innovations are introduced in schools and when computers break down. In Ghana, Agyei and Voogt (2011) found that teachers' perceived lack of technical support was a barrier to technology integration. Other studies have also indicated that teachers encounter challenges in technology adoption due to lack of technical support (e.g., (Lim and Khine, 2006; Kumar *et al*., 2008; Tezci, 2011)).

In Kenya, Wanjala *et al*. (2011) examined the factors that are significant in in-service training that contribute to efficacy of secondary school teachers' use of ICT in their instruction. In the study conducted in Bungoma district, Western province of Kenya, it was found that teachers had limited access to computer hardware, lacked the appropriate subject content software, and lacked support from administrators. To overcome these challenges, the researchers recommended that funding ICT implementation be enhanced as well as redesigning the school

curriculum. In summary, the findings from these studies reveal that a lack of technology infrastructure and resources inhibits teachers from adopting technology in the classroom. In addition, in schools where technology is available, inaccessibility to technology and lack of technical support reportedly limited teachers from using technology in the classroom.

## 2. STATEMENT OF THE PROBLEM

While evidence on the extent of technology adoption in education is well established in developed countries, little is known about the same in developing countries, Kenya included. Recently, Kenya began building technology infrastructure for schools and providing technology resources at various levels of education. However, despite these commitments as well as other steps taken to ensure schools are technologically equipped, the challenges of investing in extra classrooms, computers as well as other technology infrastructure to support technology adoption in schools still persist. Likewise, though evidence from numerous policy papers documents various challenges; there is limited empirical data that reveals how teachers are coping with new demands of technology in the classroom or lack of it. Of interest to this study is how mathematics teachers who have been tasked with improving the quality of teaching mathematics consistent with the goals of the Kenya Vision 2030 are coping with the new demands.

Observing from a traditional point of view, teaching and learning of mathematics has mainly focused on paper and pen on one hand, and chalk, talk and blackboard on the other hand even though with the recent technological resources becoming available, there is a new demand requiring teachers to change their instructional styles. With observers pointing out that there is no tangible evidence that these changes have resulted in meaningful adoption of technology in the classroom (Ertmer and Ottenbreit-Leftwich, 2010) it is important that as the country moves slowly towards implementing computers in schools to support students learning, researchers and educators examine how availability of technology resources influence teachers' decisions to adopt technology or not. This study, thus intends to assess the influence of technology resources on mathematics teachers' decisions to adopt technology in the classroom as a way of contributing to the ongoing debate.

## 3. THEORETICAL FRAMEWORK

The study adopted Rogers (1995) diffusion of innovations theory to investigate the research problem. According to this theory the diffusion is a general process that does not lean towards a particular discipline and is influenced by who the adopters are and the place where diffusion is taking place. For clarity and efficiency reasons Rogers categorized adopters of an innovation on the basis of their innovativeness and included (1) the innovators, (2) the early adopters, (3) the early majority adopters, (4) the late majority adopters, and (5) the laggards. Specifically, findings showed that the adoption rate could be modeled so that adopters' categories fall under a bell curve with the innovators being at the lower tail of the distribution (2.5% of the adopting population), followed by early adopters (13.5%) then the early majorities forming a large segment of the adopting population at (34%), followed by the late majority at 34%, and at the upper end are the laggards at (16%), at the point where diffusion of innovation is complete (depending on the rate of adoption) .

In addition to adopter categories, Rogers' further categorized adopters based on adopters' characteristics such as the social economic status, personality values, and communication behavior. Following these characteristics Rogers' categorized the innovators, early adopters, and early majority as early adopters while late majority and laggards were categorized as late adopters. The current study categorized participants as either early or late adopters based on whether or not they had embraced technology. Therefore, by including early and late adopters, the study intended to underscore the determinants of adoption of technology for the two categories of adopters.

## 4. RESEARCH METHODOLOGY

### 4.1. Research Design

A qualitative study was designed to collect data, analyze and report the findings. A multiple-case study (Yin, 2009) as a strategy of inquiry in collecting and analyzing qualitative data, and reporting the findings was adopted which allowed the researchers to analyze the use of technology from each participating teacher and between other participating teachers. Data was collected from classroom observations, pre-and-post observation interviews, and semi-structured interviews with teachers. Triangulation of these multiple data sources ensured that the study reported accurate credible findings. Data analysis procedure involved thematic analysis which was used to create a portrait of each teacher.

### 4.2. Research Sites and Participant Selection

The study was conducted in Nairobi County, the capital city of Kenya and one of the 47 devolved units. Six mathematics teachers from five public secondary schools participated, the schools being selected on the basis of having technology resources and infrastructure while the participants were selected based on the maximal variation principle (Creswell, 2008) which identified individual participants who differed on some characteristics (e.g. technology knowledge and skills, training, gender, etc.).

### 4.3. Findings

The findings are described on the basis of early or late adopters of technology. Each category had three participants. Those in the early adopters' category included Gatimu, Hamisi and Musyoka while the late adopters' included, Shiro, Awiti, and Amina. While the early adopters had embraced technology for their personal as well as classroom use, the late adopters had not.

#### 4.3.1. Early Adopters

*Gatimu.* An inquiry made from Gatimu on whether his school had supported him to adopt technology, indicated that the school had two smart boards, one being in the library and not being put into good use. According to him, "if it was put in a classroom it could be put to good use". Presently, the interviewee noted that there is a very high demand for the one accessible. "You want to use it, another teacher has booked it" (Gatimu, Interview Data, lines, 131-132). This implied that while the demand for the accessible smartboard was high, accessing the other smartboard from the library was considered a waste of time because it meant change of rooms. In addition, interviewee thought that smartboards were too expensive and there was no need to put up more at the school. Instead, he suggested that:

> Every class should have a screen and a desktop, a projector, LCD, and a desktop. This would enable every teacher, even those with phobia for using computer to use them. Through this, use of technology would be possible for almost everybody. Alternatively, the school could buy a laptop for every teacher, and let them pay for it later. Thus the teacher would be motivated to use it. (Gatimu, Interview Data, lines 323-329).

Gatimu's views were corroborated by nearly all the other interviewees especially as regards the type of the classroom setting they would wish to have which was mainly where technology was available without having the students leave the classroom. This would eliminate the frustrations that teachers go through in accessing the computer infrastructure at the computer department which according to him made some teachers not use technology. The interviewee illustrated the point with an instance when a philanthropic donated a technology system for examination purposes, the head of examination trained to handle the tool for which the computer department was not supportive He stated, "They were told I am in charge of exams so I had to be in charge of the system. "I got some training and the system is here with us and because of that, the department is not supportive" (Gatimu, Interview Data, lines 140-141).

*Hamisi.* An interview with Hamisi, noted that whereas the interviewee had the necessary technology skills, his school had not provided him with the requisite technology equipment for teaching mathematics. According to him, the main reason could be attributed to a general lack of knowledge by the school managers on teachers' technological needs. He felt that though, "this school can afford five laptops so that at any given time teaching with the technology is possible in all the four classes, the administration is not ready to provide the tools, the excuse being that it is an expensive affair" (Hamisi, Interview Data, lines 247-249). The interviewee also stressed that before introducing technology to schools, all teachers need to be equipped with technology skills which should also include those in management positions. To emphasize this, he illustrated how lack of knowledge on information technology tools was impeding acquisition of even very basic tools such as flash disks, a CD-ROM being provided when teachers orders a flash disk for their teaching needs. "If the managers could understand why a teacher asks for a flash disk [and not the CD-ROM], they could easily provide it … they are not expensive" (Hamisi, Interview Data, lines 270-271).

Availability of the Internet was also a challenge in their school. He stated, "the Internet issue needs to be sorted out. The aspect that this week there is Internet, next week there is none is so frustrating. If the school can go out of its way and invest a little more, then teachers would have unlimited access" (Hamisi, Interview Data, lines 272-275). Additionally, the respondent indicated a general lack of technology infrastructure including electricity connection. He noted, "to run a computer or an LCD projector, you need power. Except power for lighting; there are no sockets where one may plug in at the moment in the classrooms" (Hamisi, Interview Data, lines 282-284). An observation of the respondents teaching noted a general lack of instructional facilities, such as desks and computers for students. Computers were inadequate and students had to sit crowded in one corner of the room so as to have a better view of a computer screen.

Hamisi's dream is to see a situation where technology would take over students' learning and his role would be to facilitate learning. In such a scenario, he noted, "my role as a teacher would just be to chip in here and there, you know students cannot ask a computer a question, once they have made observation, they can the teacher for clarifications" (Hamisi, Interview Data, line 311-313). He implied that he looks forward to the moment when there will be a well-established technology system, when desks will be available for the students, and when students will be able to interact using the Internet. When such a time comes, he told us that teachers' roles would be to guide students and support learning. He added that, "you can even have a system where as a teacher I prepare a lesson, post in on the net and the students access it in their classroom via the net and interact with each other. This way, I don't have to move" (Hamisi, Interview Data, lines 323-325). Referring to the use of the Internet for online learning, the interviewee indicated that he had experienced this type of learning during his graduate studies when his instructor used e-mail to communicate with the students despite being out of the country. At that time he came to understand that technology has a role to play in students' learning. He wondered, "why are the Japanese doing so well in mathematics … as opposed in Kenya where mathematics is a dilemma. I would like to think that technology is playing a great role" (Hamisi, Interview Data, lines 333-336). According to him, the Japanese students were managing to excel in mathematics compared to the Kenyan students because of technology used in teaching and learning.

*Musyoka:* An inquiry from Musyoka on how his school had supported him to integrate technology in mathematics teaching, yielded a response indicating that, "to some extent there is infrastructure and because there is infrastructure, at least I can use the infrastructure in my own way" (Musyoka, Interview Data, lines 241-242). According to him, the school did not have most of the technology infrastructure he needed for his classroom activities and he had purchased some of his own to supplement what was provided since he noted that a request for even small things took too long to be provided. He noted, "there are things which are easier to achieve on my own than when I involve others" (Musyoka, Interview Data, lines 245-246). He implied that having his own technology tools was convenient because the school would not or take too long to provide such technology when he needs it.

Just like the other interviewee, Musyoka stated that their school's Internet service was down and the school was looking to have it restored. To ensure his work did not stop, he used his mobile phone to access the Internet. When we observed his class, Musyoka had a smart phone that he used to record classroom lessons so that he could reflect on his lesson at his free time. In fact, he sent me an e-mail attachment of some previous class recordings he had saved on his cell phone that he wanted me to listen to just in case we needed more data for our research. In addition to smartphone, Musyoka owns a laptop and an Internet modem that he uses for his classroom teaching. He noted, "basically all my lessons are prepared and done on my laptop. Though the school has its laptops in all cases, I don't think I have used the school's [laptop]." (Musyoka, Interview Data, lines 395-397). In response to an inquiry on why he does not use the school's laptop, he stated:

> The school computer is not sufficient for all of us including the school secretary. In most cases, the priority of use goes to the secretary to do the administrative duties. This means it cannot be available for use at all. Since not everybody can use it at the same time, there is competition for its use. (Musyoka, Interview Data, lines 399-403).

This implies that limited availability of technology resources was a problem that had created competition for the limited resources by the teachers and the administration. Additionally, the interviewee found the computer studies department to be a hindrance to technology adoption. He stated:

> I think the idea of bringing computers into the computer lab has also brought a wrong impression; these computers are for teaching mathematics but they are taken to be for teaching computer studies. It is totally wrong for the computer studies teacher to purport that since the computers are in the computer laboratory, then they are meant for computer studies. Since the teacher is in charge of the room, when he is not here, the room is always locked and to access one has to really explain why. (Musyoka, Interview Data, lines 403-409).

This emphasized the problem of accessing the computer lab due to the perception that computers are meant for the computer studies department. The computer lab personnel controlled the users of the computers at the lab. Musyoka, therefore had his own laptop so that he does not have to explain to anyone if he needed to use the computer it.

The issue of local digital content that was user friendly to Kenyan mathematics teachers was also a challenge according to Musyoka. He noted, "we may have presentations from elsewhere, which therefore may discourage teachers from using however open they are (Musyoka, Interview Data, lines 468-472). He indicated that digital content from elsewhere that does not fit the local curricula could discourage teachers from using technology. Lastly, he recommended that technology infrastructure needs to be upgraded to keep pace with current technological innovations because, "some of the machines we have cannot carry out some operations because they are based on an older and outdated technology, so to say" (Musyoka, Interview Data, lines 473-475).

### 4.3.2. Late Adopters

*Shiro.* When Shiro was asked what technological resources she would like to have in her classroom, she said "maybe more laptops and projectors. We only have one projector and I think each department has a laptop. You know I can go to class because I have a lesson when another teacher also has a math class. So maybe additional laptops could do" (Shiro, Interview Data, lines 144-146). According to Shiro, the school had one projector and every department had a laptop. Her observation was corroborated by Amina, another participant, who stated that it would be difficult for her to adopt technology in classroom because she would need to move technology equipment from class to class because those available were inadequate. She suggested that all classrooms be equipped with technology to avoid such movement.

*Awiti.* The interviewee indicated that their school had a computer lab that was used for computer studies. He told us that until recently the school had very few computers and that some were very old and not functioning,

which complicated the teaching and learning of the computer lessons. For this reason, the lab was very unpopular with students and the teachers alike. This according to the interviewee made most students "to opt for other subjects like music, agriculture and business" (Awiti, Interview Data, lines 101-102). The situation however improved after a donation of 60 computers by a benevolent organization. Again he noted that within the country, there are so many schools that did not have computers and he suggested that if somebody donated such computers to these schools to some extent that would support teaching and learning. According to Awiti, "investing more in the provision of computers for schools is necessary" (Awiti, Interview Data, lines 313-314). Digital content was also noted to be a challenge:

> Very few materials are being produced for educational purposes so that even the heads and teachers don't know what is available. We are not able to use them because, one, they are not there, and two, we don't have enough resources so we will not start going to invest in the unknown. (Awiti, Interview Data, lines 251-255)

The situation was made worse by lack of empirical data on best practices that one could adopt. He noted, "you try to check, especially within our curriculum; there is either minimal or no point of reference … that you can base your work on" (Awiti, Interview data, lines 133-135). In other words lack of local digital learning materials was in itself a demotivating factor. Awiti noted that teachers were forced to spend a lot of time preparing for technology based lessons. As a remedy, he suggested that mathematics teachers and technology experts should develop digital-content materials which should be made mandatory for adoption by teachers. At the same time, the interviewee noted that some of the software that was installed in the computers at their disposal was, "mostly on concepts that were meant for lower grades of students. At this level, we require software that can give very accurate results e.g in drawing graphs/curves" (Awiti, Interview Data, lines 137-142). Additionally, and with installation of the right software, he suggested that teachers be trained on these "special software" to make work easier, for instance, the abstract areas in graphing. Specifically, he indicated that:

> Graphing, as an abstract concept is better conceptualized through visual than blackboard because one will be able to label them correctly. I don't know how to draw a graph on a computer but if I use software, I would just provide specifications and the software would do it for me and in real life which is very interesting. The same is true also for accurately plotting on the graph." (Awiti, interview data, lines 143147).

An assessment of the software installed in the computer used by the interviewee in his office showed it had "a basic Microsoft Word" which he was familiar with. The interviewee confessed that: "I don't know how to use any other apart from this software which I have worked with and can do mathematical programs." In the process of operating the system, we noted that the interviewee was a bit clumsy in his operations. The observation thus noted the challenges faced by the teacher including in trying to copy-paste a video to Microsoft Word on his computer. This was the main reason why he does not integrate technology.

It was also noted that Awiti's school had a computer lab which he acknowledged he had access to as long as it was not in use by other teachers and students. Just like the other interviewees, Awiti confirmed that there was an impression among teachers that the computer lab was for the computer department and that "it is mainly being used for teaching computer studies. You see in this school, computer studies is compulsory in Form one and two … so the computer lab is mostly for computer lessons" (Awiti, Interview Data, lines 86-88). In short the interviewee corroborated the assertions of the other interviewees that the computer department was a hindrance to technology adoption in mathematics teaching.

*Amina.* Amina to begin with indicated that she had training in computers and could use computer to teach mathematics. However, she acknowledged not using technology despite having training on technology use. Asked why this was so, she stated, "there is no projector and the computers are not enough" (Amina, Interview Data, line 130). An interaction with the interviewee during her class confirmed that the classroom did not have any

technological resources or infrastructure. According to her, for a school like theirs with 20 lessons per day and 25 classrooms; it would require enormous resources for the school to acquire computers for these classrooms. It was also noted that the school had a huge computer lab. When asked whether she knew what went on in the lab she retorted:

> "Well, we have never even bothered. I hear that they teach computer literacy and it is mainly for the computer department, and maybe they would not want any other department to interfere. Because you bring some information in a flash disk and they bring virus and they complain and I don't know what … To avoid all that, stick to your piece of chalk and textbook. So going there, starting to request and they also have [inaudible] because every class learns computer in this program, so it is like every lesson there is computer; when will the math teacher have access?" (Amina, Interview Data, lines 155-162)

From Amina's perspective, the computer department at her school was a hindrance to technology adoption for mathematics teaching. First, she noted that the lab is very busy because all students in the school are required to take a computer class in the lab. Second, there were fears of people infecting the computers with viruses from flash disks and this makes them to stay away from using the computer lab. In the same breadth, Amina, in reference to a government project that aims at implementing laptops in primary schools, provided an interesting view of rural schools and how they may end up struggling with technology adoption;

> "There is no electricity in this country, leave alone power, food, and some areas, not all areas, there are no schools. Children are learning under a tree. Where there are classrooms, there are no windows. Where will these computers be stored with insecurity in this country?" (Amina, Interview Data, lines 240-245).

In other words, Amina saw a huge challenge for technology adoption in the Kenyan schools. She wondered how primary school teachers who most likely had not seen a computer before would embrace technology in teaching. According to her, there was a need to ensure all schools had electricity, secured classrooms where computers can be installed, and teachers trained to use computers.

## 5. DISCUSSION

In the current study, the early and late adopters suggested that classrooms should be equipped with technology facilities such as projectors and computers to enable them fully adopt technology. This finding is consistent with previous studies, such as Akbaba-Altun (2006) who examined issues related to technology adoption in Turkey and found that technology resources were the main barriers of technology adoption by teachers. Similarly, Inan and Lowther (2010) found that availability of technology was related to technology use. In short, evidence indicates a strong relationship between technology adoption and the number of computers available in the classroom (Becker and Ravitz, 2001). Additionally, the study noted that the early adopters had their own laptops, smart phones, projectors, and Internet modems to support them in adopting technology in teaching. Such findings are consistent with Khambari *et al.* (2009) who found that owning laptops helped teachers to gain confidence, increase mastery of technology skills, and improve quality of instructional materials.

At the same time findings showed that the early adopters had adopted technology in their teaching because they felt it was beneficial to them and their students. This is in tandem with observations of Rogers (2003) notion of perceived attributes of technology; as per the attribute, the early adopters had recognized that technology had relative advantages and that technology was compatible with their classroom needs. Rogers asserted that "the greater the perceived relative advantage of an innovation, the more rapid its rate of adoption will be … and relative advantage is positively related to its rate of adoption" (p. 15). It means that as individuals pass through the innovation-decision process they look for information about an innovation in order to ascertain its usefulness. Similarly, according to Rogers, compatibility of an innovation is positively related to its rate of adoption. In this regard, the early adopters recognized that technology met their teaching needs and that technology was compatible with their values and beliefs about students' learning and classroom past experiences.

However, for the late adopters, they did not recognize technology as having relative advantages to their teaching, or they believed that technology was not compatible with their teaching processes. This suggests that the availability of technology did not guarantee technology adoption (Cuban *et al*., 2001) among the late adopters. The late adopters in the current study perceived that technology did not save them time in completing the syllabus, did not prepare students to sit for the national examination, and most of all technology did not add value to students' learning. Additionally, the study noted that both early and late adopters felt that technology was complex to use even where it was available. According to Rogers (2003) complexity of an innovation is negatively related to its rate of adoption. Data analysis revealed that teachers who found technology complicated to use did not use it. This problem was implicated to lack of adequate technology training.

The department of computer studies at schools was also found to be a barrier to technology adoption among the early and late adopters. Teachers did not have free access to technology resources in the department of computer studies, an opportunity for which they wished to. In consideration to Rogers' attributes of triability (to experiment) and observability (to view) of an innovation, the participants did not have opportunities to experiment with technology or watch exemplar teachers try out technology in the computer department. On triability, Rogers assert that "the personal trying of an innovation is one way for an individual to give meaning to an innovation and to find out how it works under one's own conditions" (p. 258). The mathematics teachers' lack of access to the computer lab created a barrier for them to try new ideas that could lead to full-scale adoption of technology. Regarding observability Rogers argued that, "the easier it is for individuals to see the results of an innovation, the more likely they are to adopt" (p. 16). Mathematics teachers did not have opportunities to observe and try certain technology applications for classroom practice which impacted negatively on adoption.

## 6. RECOMMENDATIONS

The study therefore, suggests that schools develop technology plans to facilitate effective technology adoption, school managers leading in formulating the plans based on research and successful models. Important for consideration are the skills that students should acquire from technology, sources of funding for technology resources, technology resources, technical support, teachers' training needs, and structure and delivery of lessons. Technology planning committees must involve all education stakeholders including parents, students, teachers, and technical experts so that all concerns and issues are addressed in advance. When all education stakeholders are encouraged to participate in decision making at the schools, then technology adoption is likely to occur.

**Funding:** This study received no specific financial support.
**Competing Interests:** The authors declare that they have no competing interests.
**Contributors/Acknowledgement:** All authors contributed equally to the conception and design of the study.

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