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Exploring ICT Adoption in Teaching and Learning of Science: A Case of Senior Teachers in Kenya

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Abstract

This study was conducted in Homa Bay Sub County, Kenya to explore the adoption of ICT among senior teachers, aged between 45-60 years, in teaching and learning of science. A qualitative research approach using a case study design was employed. Eight secondary school senior teachers of science, 2 females and 6 males, within Homa Bay Sub County were purposefully selected. Semi structured interviews were conducted one-on-one basis followed by classroom observation and document analysis. Analysis of the data revealed that senior teachers of science generally integrate ICTs in planning, assessment and in classroom teaching; however pedagogical preferences and teacher's workload had an influence on their choice of pedagogy. Subsequently, traditional pedagogy dominated their classroom lessons while ICT partially integrated as complementary to teach specific topics in science. The

major factors revealed, that stalled ICT adoption in science teaching among the senior teachers, were insufficient technical support that reduced confidence of ICT integration, scarce practical training on ICT usage, basic expertise level in using ICT and inadequate ICT infrastructures in schools. Nonetheless, the senior teachers of science acknowledged that ICT is convenient and beneficial in teaching and learning. Thus, for increasing ICT integration by senior teachers of science in teaching and learning, it was recommended that the senior teachers of science be exposed to consistent ICT training to be abreast with current ICT knowledge, policies developed for teachers' preparation and professional development be supportive and emphasize ICT integration in pedagogy.

Keywords: ICT adoption, senior teachers of science, pedagogy, ICT integration in teaching and learning, diffusion innovation

1. Introduction

The high potential conferred to ICT in the 21st century has necessitated its integration in teaching and learning of science. The COVID 19 pandemic compelled the education sector to embrace ICT to reach learners away from educational institutions. Lawrence and Tar (2018) posit that ICT adoption enhances a perfect learning environment befitting this digital age. Ideally, Abdullahi (2014) opines that science and ICT are interrelated and should be a necessity of an educated individual. Likewise, Ültay and Ültay (2012) believe students need to comprehend advancements and improvements in ICT long even after school. Indeed, learners need technological skills to solve daily life problems in this time and age in enhancing development of constructive thinking. Contrary to these positive views on ICT, Trucano (2016), argues that ICT integration has disrupted traditional educational practices, overburdened the teachers and exasperated digital divide in education.

Worldwide, there is increased pressure to incorporate ICT in education policies. The 2015 UNESCO QINGDAO declaration, in China, acknowledged it strengthen the education systems; promotes dissemination of knowledge, access to information and improves learning transforming education for better attaining SDG4 (Miao et al., 2019). In Africa, adoption of ICT in education has been stalled by insufficient ICT infrastructure, negative attitude towards ICT and level one digital divide. African countries are still yet to enjoy the full potential benefits of ICT in education (Souter et al., 2014). Nonetheless, effort has been increased in Africa to foster ICT adoption in education. The 'Dakar framework for action' was steadfast in promoting ICT adoption in education in sub-Saharan Africa enhancing 'Education For All' (UNESCO, 2000). The launch of New Partnership for Africa's Development (NEPAD) e-School demonstration Project, in 2002 by AU, trained and supported teachers in ICT integration and availed relevant digital content for the curriculum (Farrell et al., 2007).

In East Africa, Savec (2020) posits that overloaded science curriculum has negatively impacted on ICT adoption in science education. Science teachers prioritise syllabus coverage at the expense of integrating ICT to enhance critical thinking for problem solving. Although there are many factors that makes East Africa lag in ICT adoption teacher's age is profound (Voogt, 2004). Similarly, Oyelaran-Oyeyinka and Adeya (2004) in their study that incorporated Kenya, affirm that teacher's age affects ICT adoption in learning.

ICT integration makes learning of scientific concepts less abstract and adopts it to the learners' life situations. Learners of this 21st century need to learn ICT skills to promote creative thinking and to solve their daily life problems (Turiman et al., 2012). However, many studies show that the senior teachers are conservative preferring traditional teaching method to ICT integration in learning. Prensky (2001) opines that this group of teachers were socialised without technology and tend to adopt it with difficulty. According to Neves and Amaro (2012) to effectively empower the senior teacher's usage of ICT, it is imperative that their pattern of usage be examined. It is against this backdrop that this study aimed to explore the extent of ICT adoption in teaching and learning of science among teachers aged 45 years and above and to answer these questions:

i. How do senior teachers integrate ICT in planning science lesson?

ii. To what extent do senior teachers use ICT in carrying out teaching and learning activities in science lesson?

iii. How do senior teachers integrate ICT in assessment?

iv. What problems do senior teachers encounter in adopting ICT in teaching and learning of science and what could be the possible solutions?

1.1 ICT in Science Education

The information age has rapidly impacted society's advancement in science education. Abdullahi (2014) opines that ICT develops students' problem-solving skills and higher order of thinking which prepares them to solve real life challenges. Profoundly, teacher's role in ICT integration in science is critical. Mahdi and Al-Dera (2013) note that ICT without teachers cannot establish a better environment for teaching and learning. However, Sumi and Shaikh (2021) argue that despite science teachers' knowledge on ICT, its implementation in the classroom is very inadequate. Fernandes et al. (2019) argue that components of ICT-based science that are essential in learning depend on the teacher's pedagogical methods. In addition, Osborne and Hennessy (2003), acknowledge that ICT integration is stalled by teacher's reservations and that effective ICT usage is mostly confined among minority enthusiastic teachers. Therefore, it is imperative for teachers of science irrespective of their ages to master the skills of ICT usage to avoid being a hindrance to its adoption in teaching and learning of science.

1.2 Teacher's ICT Skills and Usage

The world is dynamic and so are the educational activities including the teaching methodologies. Aina (2013) argue that the learning world is beyond the traditional teaching method of talk and chalk. Thus, whoever is planning to be a teacher must integrate technology in their classes. Mirzajani et al. (2016) posit that appropriate ICT skill influences ICT utilization whereas inadequate technical support stalls it. Similarly, Mwalongo (2011), in his qualitative study in Tanzania, explicates that teacher's ICT competence is influenced by training while usage frequency is determined by access. Abdullahi (2014) notes that training of teachers on ICT integration has resulted to more success in learning of science compared

to other subjects**.** According to Saxena (2017), training of teachers fills the gap on ICT knowledge and skills and enhances their ability to translate these skills into their pedagogical practice. Amid increase in ICT integration, it's prudent to examine the pattern of usage among the older senior science teachers, whom according to Prensky (2001), tend to adopt technology with difficulty.

1.3 Age and Experience in ICT Integration

Research have shown that age and experience in teaching have an impact on the adoption of ICT in education (García et al., 2014; Wong & Li, 2008). In a study involving 250 schools, Lau and Sim (2008) noted that senior teachers were more likely to adopt ICT in teaching. Ideally, they could easily integrate ICT into teaching due to long teaching experience and basic ICT skills. However, Jennings and Onwuegbuzie (2001) argue that younger teachers are more positive towards ICT than the senior teachers. Similarly, Inan and Lowther (2010) asserts that ICT adoption in teaching and learning decreases with age and teaching experience. Subsequently, research has shown that negative attitude and inherent resistance to change by senior teachers significantly hinder ICT integration in classroom teaching (Bingimlas, 2009; Gomes, 2005). So, while experience could be a positive factor towards ICT, attitude could be a hindrance and needs to be further examined.

1.4 Theoretical Framework

This research study was anchored on diffusion innovation theory. The theory recognizes different adopters' characteristics which include innovators- those quick to try innovations, early adopters- those that are quick to embrace change becoming opinion leaders, early majority- those who wait to see evidence of success before adoption, the late majorities- who are sceptical of change and laggards-the conservative group bound with traditions. As noted by Prensky (2001), senior teachers are conservative and sceptical in adopting ICT, thus associating them to late majorities and laggards. Subsequently, the theory further postulate that certain characteristics impact adoption of ICT in a social organization: relative advantage, compatibility, complexity, trial-ability and observability of the innovation (Ntemana & Olatokun, 2012). Relative advantage relates to the perception of the innovation being better than the traditional idea while complexity relates to difficulty of technology used, compatibility is with reference to the individual's values and experiences; trial-ability focuses on the extent at which the technology has been experimented before adoption whereas observability relates to the extent to which the innovation gives tangible impact (Rogers & Scott, 1997). Consequently, as deduced by this theory, Rogers (2003) argues that innovation characteristics as perceived in a social system affect the rate at which it is adopted. Therefore, this theory profoundly informs this study which seeks to explore the senior teachers' ICT adoption in teaching and learning of science amid comparative perceived influence of traditional teaching pedagogy.

2. Methodology

Qualitative research approach was adopted in this study. As affirmed by Denzin and Lincoln (2018), the approach facilitated assessment of interactions, experiences and documents of

respondents in their natural setting hence creating room for giving detailed data. A case study design was employed to gain a holistic explanation of the homogenous group of senior science teachers to get answers for "why" and "how" they adopted ICT in teaching of science. Eight science teachers aged 45 years and above, teaching in public secondary schools and still working under the Teachers Service Commission in Kenya, within Homa-bay Sub County were purposively selected. Two of the respondents were female while six were male. They least had 15 years of teaching experience with the highest having the 22 years. Purposive sampling according to Lodico et al. (2010) allowed for handpicking of the respondents befitting the required research characteristics. The eight respondents were subjected to separate semi-structured face to face interviews, overt lesson observation and their documents analysed to capture their perception and skills on ICT integration. Documents such as schemes of work, lesson plan, analysed results, progress record, timetable, examination bank and teacher's notes in custody of the individual senior teachers were analysed to ascertain the input of ICT in their preparation, usage, maintenance and storage. Qualitative data analysis was employed to analyse interview transcripts, classroom observation data, document analysis and researcher's field to identify common patterns and themes that emerged as informed by the theoretical framework.

3. Results

3.1 Senior Teachers' ICT Usage in Teaching and Learning of Science in the Classroom

The eight respondents were interviewed on this subject to seek their perception and knowledge on ICT integration in classroom teaching. Findings revealed that ICT is used in simplification of abstract concepts, information presentation and learners' engagement. In simplification of abstract concepts, most of the respondents attested using simulation and videos to illustrate complex processes as illustrated by Malaki, "…When teaching extraction of sulphur, I use computer to simulate process. Students see the simulation, as I explain the concept."

The interviews data also revealed that the senior teachers employed ICT to project notes when teaching science lesson. Most of the teachers had stored soft copies of notes in their smartphones. It was noted that learners had bounteous time to take notes saving lesson time as Leaky elucidated, "…with the projector and the PowerPoint application, the key points are easily projected. This always gives learners ample time to copy and discuss with the peers during the lesson."

Subsequently, students were given images printouts, notes and questions for discussion. Most of the respondents had both printed and handwritten notes. The printouts of lesson notes or images are prepared earlier and given to the students during the lesson as noted by Malaki, "… I use ICT at times to prepare printouts for Chemistry practical lesson. This fully engages the learners during the lesson…" Leaky acknowledges the essence of downloaded image printouts from the internet. He notes, "some images that may not be clear in student textbooks. I download them from the internet. These images are in three dimensions. They can be manipulated so that all the parts are visible." However, in classroom lesson observation, Leaky above would not go beyond the ICT basics of just projecting the

downloaded 3D images for learners to see.

It was vivid that the senior science teachers also employed ICT in the classroom to engage and keep learners active as Evans explicated, "ICT tools usage engages the students more compared to use of traditional method. Their interest is developed improving their understanding."

Nonetheless, during classroom observation, it was noted that the traditional teaching method dominated the lessons of most senior teachers of science in this study. The ICT tools were apparently used in a limited time during introduction and lesson development. The smart phone was the major ICT tools used where some teachers used the Google search engine to source for information and referred to notes stored in them. Those respondents who completely ignored ICT integration in the classroom session on further probe seemed to prefer traditional teaching method citing that it allowed learners to learn by doing and consequently provided a sense of touch as Peter noted, "overuse of ICT makes learners lazy, their handwriting becomes poor due to reading written text only... Learning also takes place by doing, but ICT give solution."

On frequency of integrating ICT, most senior science teachers preferred usage of both traditional pedagogy and ICT in teaching and learning. Six out of the eight respondents claimed to integrate ICT partially in teaching and learning of science. For instance, it was noted by the respondents that they integrated ICT mostly when teaching topics that entailed complex processes. Nonetheless, there was consensus that other topics would be taught easily using the traditional pedagogy as explicated by Wallace,

I use ICT partially in topics like cell division, evolution and reproduction in plants. For instance, illustrating double fertilisation in plants using a video clip. There are certain topics that works well with ICT, while others don't.

Thus, ICT is integrated by senior teachers of science as a complementary to traditional teaching method.

However, one senior science teacher, Martin, fully integrated ICT frequently in teaching and learning of physics as evident in classroom observation and document analyses. The respondent was a fully trained computer studies and physics teacher and enjoyed the benefit of skills possessed and full access to ICT lab in which he also taught physics subjects as he expounds,

I am well-trained and purely use ICT in teaching. All my lessons are done in the computer lab. I make a folder with tasks and share with learners through the network and mark whatever they have done through the server which is my laptop.

The privilege of access to ICT resources computer lab and versed training was an impetus to increased frequency of ICT integration in teaching and learning of science by the teachers.

3.2 Senior Teachers' Usage of ICT in Planning and Assessment

Interviews and document analysis were employed to source information on how senior

science teachers integrated ICT in planning and assessment of teaching and learning activities. ICT integration was employed in access and sharing of information between colleagues, assessment of learners' performance and in preparation of professional documents, notes and test items.

To access and share information for planning and assessment, most of the respondents resorted to education sites, search engines like Google and interactive technologies like YouTube, WhatsApp, and Telegram as mentioned by Queen,

I use ICT when making notes and doing research. Typing my exams is inevitable. WhatsApp is very helpful to get teaching resources from colleagues, and even telegram.

It is evident that senior teachers highly integrated social media in enhancing assessment and planning for teaching and learning. WhatsApp platform was the dominant social media application preferred by the senior science teachers.

Subsequently, the respondents noted that they integrated both ICT and traditional method in seeking information when planning for teaching and learning, for example sourcing information from textbooks as posited by Malaki, "I use ICT at times, but mostly in preparation for the lesson we use the traditional method because we don't even have those gadgets." It can be deduced from the above response that, while ICT would make it easy for the senior teachers of science to access information easily for planning and assessment, some of these teachers were still conservative and are held hostage by the traditional methodologies.

In learners' assessment, the study revealed that most of the respondents had bank of questions in soft copies used during test construction for summative assessment. Malaki said,

ICT saves time and energy. Writing exams and making the marking scheme has been made easy. Typing is easier, and in case of errors editing the whole document, undo and the rest is easier. ...I have exam bank; science practical, theories and mock papers for reference.

However, most of the respondents preferred the traditional method when conducting formative assessment in the classroom as Peter acknowledged, "To assess whether learners understand I observe them, ask questions, gauge their response and participation. Most formative assessment in class is just traditional." Surprisingly, all the respondents were able to interact and effectively use the exam analysis. All teachers were mandated by the school to input results of their subjects on their own, edit, make corrections to marks, and publish as Wallace elucidated,

We are required to use ZERAKI exam software system. It is very easy and very efficient. We use our phones to key in the data once, then we process the results. All teachers are required to input their own results.

It was evident that if senior teachers of science are mandated by the institution to adopt ICT its success was guaranteed.

Although senior teachers of science kept soft copies of professional documents like schemes

of work and lesson notes, most of them kept handwritten lesson plans as noted by Teacher Wallace, "the lesson plan are usually handwritten while the schemes of work are of soft copy which I easily update." Most of the prepared professional document for planning and assessment were downloaded from various educational sites and shared through WhatsApp. They were later edited by most respondents to fit their needs. Thus, it was evident that senior teachers of science have basic knowledge and skills on how to manipulate ICT tools to perform task successfully.

3.3 Barriers and Solutions of Adopting ICT among Senior Science Teachers

On this question, the respondents were asked to explicitly describe the challenges that deter them from integrating ICT in teaching and learning. Solutions for the described challenges from the point of view of those senior teachers were also sought. The following human and technological challenges were explicit:

i) Lack of sufficient training

It was observed that most of the respondents had basic ICT level. Most of the respondents resorted to using traditional pedagogy frequently depicting inadequacy of ICT skills. Sufficiency in ICT training is an impetus to frequent integration of ICT use as Martin acknowledged, "I am well trained in ICT. So, am more advanced in ICT integration and purely use it in teaching" Other respondents were hesitant to use the new technology citing inadequacy of training in ICT as Evans noted, "…I started teaching when training on ICT was not available. Young teachers nowadays are in the field with ICT knowledge from the universities. So, it is easier for them compared to us who went through the system minus ICT." Thus, lack of initial training apart from reducing confidence, has rendered the senior science teachers handicap to usage of ICT.

On the question of solving this gap on training, the respondents suggested that ICT training should start early and prioritised during the teacher preparation as Evans elucidated, "ICT should form part of teachers training at the university level and should be relevant for secondary education. There is need to integrate ICT in teaching practice."

The above respondent opined that there is little connection between the teaching methodology taught at the teachers training colleges and the reality of pedagogies the teachers use in school**.** They are predominantly traditional hence limiting acquisition of ICT skills and knowledge by the student teachers.

ii) School leadership and ICT

The senior teachers revealed that the school leadership had an influence on ICT adoption in the institution. Leadership influenced availability, access, capacity building in ICT skills and knowledge and management of ICT resources, which directly influenced ICT integration in school as elucidated by Martin, "the managers of the schools like principals are not knowledgeable in computers and when they source somebody from outside, the person may remove vital parts of the computer unnoticed." In addition, Florence stated, "If possible, the school should source for funds to purchase the ICT gadgets. However, administration that has

not seen the need for availing ICT resources need to be enlightened."

On seeking for solution to the negative impact of school leadership on ICT adoption, the senior teachers of science expressed the need for paradigm shift that would ensure the administrators accept ICT adoption. It was revealed that there was need to sensitize the principals on the benefits of ICT adoption in schools as Leakey noted, "…school administrators should acknowledge importance of in learning. Our board of management must give it priority." School leadership is crucial in ICT adoption in education. From the above responses, the senior teachers of science noted that ICT initiatives would be undermined by inadequate support from the leadership of schools.

iii) Technological failures

Profoundly, senior science teachers were worried of non-anticipated failure and or breakdown of the ICT tools and sporadic electricity supply which would negatively affect the flow of the lesson. Most of them noted that this could result to time wastage or even cause them embarrassment as mentioned by teacher Wallace, "…power loss sometimes interrupts the lesson making you to start afresh, and the rebooting process sometimes takes long. Use of technology sometimes can fail you." Ideally, avoiding interruption, classroom control and evading uncertainty during the science lesson was much important to the senior science teachers.

When the senior teachers were asked to suggest solution to the anticipated technological failure, they asserted that there was need for employment of adequate ICT technicians to offer ICT ideas and skills to the teachers, enhance maintenance of ICT equipment as claimed by teacher Malaki, "we can sensitise the principal to employ ICT officer just like the lab technician. They will prepare for ICT usage, check for sound effects making it easy for the teacher to integrate ICT." Thus, mechanisms need to be established to facilitate adequate access to technical support by senior science teachers for successful ICT adoption.

iv) Teacher's workload and pedagogical preferences

Senior teachers of science had concern over huge workload which limited ICT integration in their classroom. The pressure to cover the syllabus in time shaped the teacher's preference to traditional teaching pedagogy negatively impacting on ICT adoption as explicated by teacher Queen, "Use of ICT takes longer compared to traditional teaching method during lesson preparation. Something I would easily demonstrate physically would take longer when using a laptop. Traditional teaching method is less time consuming and faster in syllabus coverage." The preference to traditional teaching pedagogy has overshadowed the ability of the respondent to adopt ICT as an innovation.

On the other hand, it was identified that the top barrier to successful integration of ICT in schools by the senior teachers in teaching of science was infrastructural deficit. The respondents noted that the student–computer ratio that would enhance more teacher-learner engagement was extremely low in the various schools and hence the dominance of traditional pedagogy as mentioned by Martin, "There are challenges of buying computers to fit the ratio of the students. Computers are still very expensive for the schools. The schools lack the

funds." Consequently, concerns were raised on absence of mobile devices among learners which limited teacher-learner interactivity as elucidated by Peter, "learners don't have ICT gadgets, if they had mobile phone which is still not applicable now, it would improve interactivity."

Other respondents reported that not only were the hardware and supporting software inadequate in school, but also expensive for independent teachers to afford. The inadequacy of these infrastructures had occasioned them to resort to traditional teaching methodologies as noted by teacher Malaki, "I don't use ICT frequently because we don't even have the tools and are expensive." The views indicate that, senior science teachers' resolution to use traditional pedagogy is due to limitations posed by inadequate ICT resources in their various schools.

To solve this issue of infrastructural inadequacy, the senior teachers of science suggested the need for the government to boost the ICT resources in schools. Many of the respondents acknowledged that the schools had inadequate funding for these projects and appealed for aid in development and maintenance of ICT equipment as depicted by teacher Martin, "Computers are still very expensive for the schools. I appeal for the ministry of education to find a way of buying computers, building computer labs and networking and maintaining them." It is explicit that schools have inadequate funds to procure and adequately maintain ICT resources hence the need for government funding.

The senior science teachers castigated the restriction attached to the usage of ICT laboratories. In most cases, the computer laboratory was limited to students studying computer studies only as Queen elucidated, "by using questions you mark it you check and see their response to determine their understanding. The ICT lab is not accessible. Unless you are a computer student for a specific time you can't access the lab." Successful ICT adoption by senior teachers of science necessitates a paradigm shift on the usage of ICT laboratories in schools to accommodate all teachers and students in using ICT resources.

4. Discussion

This research aimed to explore how senior teachers have adopted ICT in teaching and learning of science. It was evident that senior science teachers integrated ICT in the classroom to simplify abstract concepts enhancing comprehension by the learners, to facilitate presentation of information and lastly to promote learners' engagement. Videos and simulations were employed to illustrate abstract processes in science topics. The above findings are in congruent with Osborne and Hennessy (2003) who noted that ICT provides varied range of tools including multimedia software for simulations and virtual experiments. Consequently, Kalogiannakis et al. (2018) noted that integrating these ICT tools promote learners' comprehension of scientific concepts. Subsequently, ICT was employed in availing notes, questions and 3-dimensional images printouts to present relevant information to engage learners during the lesson. As posited by Del Cerro and Morales (2018), 3D images fill the gap between the virtual and the real world enhancing in-depth understanding. The smart phone was the most preferred ICT tool among the senior science teachers since it was convenient. Consequently, it was explicit that the senior teachers understood the importance

of ICT integration in the classroom contrary to earlier depiction by some of previous scholars (Liu, 2011).

However, it was established that the ICT tools were apparently used in a limited time during introduction and lesson development. Most of the senior science teachers dominated their classroom lesson with traditional teaching pedagogy even though the findings revealed they had basic ICT knowledge and skills. It was clear the senior science teachers would not go beyond the ICT basics of just projecting the downloaded 3D images for learners to see. Further manipulation of the 3D image to increase interactive experience would require additional ICT skills on the part of the teacher and learners to have ICT gadgets like smart phones which were conspicuously absent. Del Cerro and Morales (2018) opines that mobile devices, computers and other detailed ICT equipment that can allow manipulation of 3D images are not available in the classroom limiting learning interactivity. Consequently, ICT was integrated in handling only limited specific topics in science. Nonetheless, Kolb (2019) argues that ICT should only be a replacement to traditional resources when there is value addition. It is however prudent to note that most of the respondent showed preference to traditional pedagogy as indicated by the low frequency of usage and are therefore not guided by the reasons posited by Kolb. As explicated by Abdullahi (2014) science teachers generally integrate ICT as a complimentary in fewer occasion to existing pedagogy in classroom teaching rather than adapting and shaping their subject contents to fully incorporate ICT. However, the dominance of traditional pedagogy, according to most of the respondents, was due to inadequate ICT resources.

The senior teachers acknowledged that they employed ICT partially in sourcing and sharing information for planning, in assessing of learners and in preparation of professional documents required for teaching and learning. It was evident that senior teachers of science highly integrated social media for sharing information for assessment and planning. WhatsApp was the dominant social media application preferred. Thalluri and Penman (2015) argue that social media platforms has been key in facilitating human interactions and enhancing exchange of ideas and collaboration among colleagues. The possible reason was that social media platform, for instance WhatsApp, is easier to use and convenient especially in institutions with network access.

Traditional method was most preferred in conducting formative assessment in the classroom. It was believed to be quicker and easy to assess learners' understanding through verbal questioning other than employing ICT tools. However, summative assessment necessitated ICT integration. Most of the science teachers were able to use Ms Word application to edit, manipulate and print test items stored in the computer. Similarly, they were able to download schemes of work and notes and edit them to fit their needs. Surprisingly, the lesson plans were majorly handwritten. This was probably because they were normally prepared in a hurry. Consequently, compelling evidence showed that if the senior science teachers are mandated to integrate technology in school, ICT adoption was outstanding.

The senior science teachers acknowledged that the school leadership had a vital role to play in ensuring ICT adoption. The principals influenced capacity building in ICT, oversaw

procurement and management of ICT resources. It was vivid that ignorance of some Principals limited access to ICT training opportunities for senior science teachers. According to Stuart et al. (2009), school managers with ICT skills and knowledge are more likely to champion the use of ICT in school. Thus, incorporating them in similar ICT training as the senior science teachers would positively impact on ICT adoption in the institution.

Similarly, the humongous benefit of using ICT including speed of sharing and access, editing of notes and downloaded schemes of work to fit personal needs and interactivity seems to necessitate use of ICT by the senior science teachers. Thus, as informed by the theoretical framework, observability, which relates to the extent to which the innovation gives tangible impact appears to inform the adoption of ICT by senior science teachers in planning and assessment. It's explicit, from the findings that, senior teachers understand the importance of ICT in teaching and learning of science and hence shaping their adoption.

It was noted that the challenges that deterred senior teachers of science from adopting ICT ranged from human, technological challenges to infrastructural inadequacy. Most of the senior science teachers had basic knowledge on ICT integration and only required regular training to be abreast with the current trends and improve their confidence on ICT usage in school. Thus, some initial training is vital for senior teachers of science to enhance appropriate ICT skills development, ideas and positive attitude towards efficient ICT use in support for learning. Saxena (2017) explicates that some of the major issues that deter effective integration of ICT in the classrooms by the teachers are inadequate training, support and gaps in ICT skills and knowledge. Although some of the senior teachers claimed to have received some basic training on ICT skills, Saxena (2017) posits that inability of the teachers to translate the ICT training received into the pedagogy limits its adoption. Becta (2004) reports that most senior teachers believe they are less skilful on ICT integration in the classroom. Thus, through training, the senior science teachers would experience direct impact of ICT integration by observation and as informed by the theoretical framework, observability is an impetus to ICT adoption.

The senior science teachers expressed the dire consequences of technological failure which included time wastage and even embarrassment in front of the learners. Lau and Sim (2008) argue that technological faults and recurring faults during the lesson, impacts negatively on the teacher's confidence and may result to reduced ICT integration in the classroom. Kiboro (2018) associates low confidence among elderly teachers with reduced ICT integration in the classroom. Thus, mechanisms need to be established to facilitate adequate access to technical support by senior teachers of science for successful ICT adoption. As suggested by Mahdi and Al-Dera (2013), senior teachers require technical support to enhance successful adoption of ICT. Similarly, ICT technicians are crucial in providing help for software applications usage servicing and maintenance of ICT resources (Minishi-Majanja, 2007; Richmond et al., 2017). This is vital to sustain full integration of ICT in classroom teaching without the limitation of time loss due to fixing configurations in ICT tools or other anticipated technical challenges.

Finally, infrastructural deficit was established to be the main constrain for ICT adoption

among senior teachers in teaching of science. The inadequate computers and necessary software applications limited teacher-learner engagement resulting to dominance of traditional pedagogy. Mutisya et al. (2017) argue that the major cause for low adoption of ICT in teaching and learning in Kenyan schools is inadequate computer infrastructures. Suggested solution was to allow learners have smart phones in school to increase teacher-learners engagement and to boost ICT resources in schools. Absence of mobile devices among learners and computers in the classroom, limits teacher-learner interactivity (Del Cerro & Morales, 2018). Moreover, the senior science teachers expressed the need for the ICT laboratories in schools to accommodate other subjects other than the normal computer studies subject. Abdullahi (2014) argues that the computer laboratories in schools need to be used in a transformative way instead of being streamlined to curriculum and pedagogy. This will be an impetus to gain and use ICT knowledge and skills with all the teachers and learners in the institution.

5. Conclusion

While it may be interpreted that senior teachers have a low preference to ICT integration in teaching and learning of science, ostensibly their usage reflects a sense of priority conveyed by the education institution to see returns on their ICT investments. The tendency to ignore ICT integration by the senior science teachers may be due to apparent vulnerability of their professional authority and position and seemingly basic ICT knowledge. There is need for senior science teachers to change their perception on ICT and accept that education is dynamic and so are learners. Ideally, pedagogical training offered to science teachers should enhance a lifelong learning development and professional practices that keeps them abreast with ICT knowledge and developments in education. In addition, senior science teachers need to reorganize their teaching and learning environment in a less traditional way by integrating ICT with new pedagogical practices. Consequently, they need to be enthusiastic to employ more ways that are innovative in integrating ICT in school. Those entrenched in the traditional pedagogy have no option, but to embrace technological changes and foster their teaching proficiency.

However, an enabling environment is vital for senior science teachers to adopt ICT. For instance, by ensuring sufficient capacity building in ICT integration and creating flexible lesson time that accommodate ICT integration in learning. Subsequently, there is need to restructure the workload of the senior science teachers and administrative responsibilities to create more room for ICT integration. Lastly, it should also be accepted by the senior science teachers that the current generation of students, Generation Z, are intertwined with digital technology and it will be a disservice if they don’t acknowledge this reformation. Thus, they should be more knowledgeable in ICT to meet expectations of their learners. Further research should focus on ways to efficiently overcome barriers to ICT adoption in schools. This is prudent since ostensibly, as indicated by the findings, ICT integration barriers are the major cause of low ICT adoption in teaching and learning of science.

6. Ethics Statement

Permission to conduct this research was sourced from National Commission for Science,

Technology and Innovation (NACOSTI) in Kenya through the County director of education Homa-bay (**MOEST/COE/HBC/ADM/11/VOL.II/14**), the Sub County director of education Homa-bay Sub County (**SCDE/HBC/ADM/VOL.1/23**) and from various school administrators where the research was conducted. Participants provided appropriate informed consent through filling out the consent forms individually as required by NACOSTI.

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Informed Consent

Obtained.

Provenance and Peer Review

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Data Availability Statement

The data that support the findings of this study are available on request.

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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