

# Teaching and Learning with Technology: Effectiveness of ICT Integration in Science, Technology, English and Mathematics (STEM) Teaching and Learning in African Digital Schools Initiative (ADSI) Schools in Narok County

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**Abstract**— The integration of Information and Communication Technologies (ICTs) in STEM teaching and learning has become a potent vehicle of effective teaching and learning experiences in the 21st century for both students and teachers in African Digital Schools Initiative (ADSI) in Narok County. The Ministry of Education, Science and Technology (MOEST) has partnered with the Global E-Schools and Communities Initiative (GESCI) because of the crucial need to integrate ICT in STEM teaching. Through ADSI, ICT infrastructure have been provided to some schools and teachers trained on model design and implementation of lesson presentation software, interactive learner-centered pedagogical strategies and collaborative learning tools to address diverse interests and needs of the learners. The study is aimed at exploring the impact of teacher training on the use of ICT tools and the STEM comprehension levels and attitude among the learners. A total of 60 teachers from 20 ADSI schools in Narok county have been purposively sampled for the study. It was found out that the training made teachers resourceful in lesson preparation using ICT tools which resulted in improved learning outcomes and improved quality of STEM teaching. Additionally, the use of ICT instilled 21st century skills on learners as learners were able to interact with ICT tools and led to incorporation of ICT-based teaching and learning. The study recommends MOEST, Kenya Institute of Curriculum Development (KICD) and other Non-Governmental Organizations (NGOs) to step up their efforts in effective training of teachers in ICT, provide adequate ICT infrastructure and set up a framework for the implementation of ICT in teaching and learning in all schools.

**Index Terms**— STEM teaching and learning; ICT integration; ICT infrastructure..

## I. INTRODUCTION

Highlight The use of technology in the 21<sup>st</sup> century has found its way into the classroom and has become a crucial tool in the transfer of knowledge. The infusion of technology in work, schools and other aspects of the society has transformed the thoughts and lifestyles of many people in the world today. The integration of Information and Communication Technologies (ICTs) in teaching and learning is the incorporation of computer-based

communication in the daily classroom instructional process. The advances of ICT in teaching and learning is a great avenue for teachers and students to improve the quality of teaching and performance.

Technology is undoubtedly crucial in the contemporary society majorly for improving teaching and learning quality because modern technology provides tools that are essential in the classroom. According to Ghavifekr et.al (2014), the use of ICT in the classroom is vital in improving pedagogical practices and students' learning. Learners have gotten familiar with technological tools and thus learn better in an ICT enriched environment. Jamieson-Proctor et al. (2013) argue that ICT tools used in schools are vital in the contribution of pedagogical aspects which have resulted in effective learning.

Additionally, ICT is potentially effective in the preparation of students for the 21<sup>st</sup> century life by endowing them with significant skills to face the challenges in future based on comprehension skills acquired through ICT tools. Hussain et al. (2011) argue that ICT is helpful in the development of competencies needed for current globalization since ICT can foster skills development, widen information and knowledge as well as boosting their motivation for STEM learning. Also, ICT tools can be used in varied ways to support students and teachers in STEM teaching which make the process meaningful and interesting. The integration of ICT in STEM teaching is crucial among the learners because it enhances hand-on technological activities designed to stimulate content retention.

Similarly, teachers are able to design lessons creatively and effectively that would result in dynamic learning, improved students' abilities and enhanced learning processes (Jamieson-Proctor et al., 2013). Through implementing the precise use of ICT in hard to teach concepts in STEM subjects, teachers are able to instil complex skills and concepts in a simple way to improve the attainment and achievement. Also, the learners are able to creatively and innovatively present topics that will lead to exchange of thoughts and ideas.

One crucial factor for ICT integration is the sufficient ICT equipment and computer labs in all the schools as these ensure that learners and teachers can easily access ICT tools. Most schools in rural areas are grappling with lack of internet

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access and inadequate ICT infrastructure. For example, there are few schools with ICT infrastructure and enjoy support from initiatives but the student-computer ration is high (Chapelle, 2011). Because of these challenges, teachers and students have encountered technical difficulties thus interrupt teaching and learning process. Schools also lack technical support and repair of computers which has discouraged teachers and students from using ICT equipment for fear of equipment failure.

The need to conduct the current study was informed by absence of related studies in the county on the integration of ICT in teaching and learning, yet this is an emerging issue in education in the world today. It is anticipated that this research will contribute to the knowledge in ICT in classroom as well as provision of useful knowledge to practitioners, educators, policy makes and researchers with affiliations to ICT in education (Hammond, 2013). The main purpose of this study is to explore the effectiveness of ICT Integration in STEM teaching and learning in ADSI schools in Narok County. Specifically, the study aims to identify:

- (i) The impact of teacher training on the use of ICT tools on learners.
- (ii) The learners' STEM comprehension levels, attitudes and knowledge towards STEM subjects.
- (iii) The impact of ICT learning strategies such as simulations, concept mapping, webquests, infographics and open education resources (OERs) on STEM subjects among the learners.

#### **ICT Integration in the Kenyan Context**

The integration of ICT in the Kenyan context present mixed feelings. MOEST has made tremendous steps in the enhancement of ICT integration in teaching and learning in schools. MOEST has realized the need for ICT tools in teaching to help the teachers in meeting the challenges of effective teaching. MOEST has equipped some schools with ICT resources through programs such as the provision of tablets to learners in class one (MOEST, 2014). The government initiated the economic stimulus project (ESP)-ICT computer for schools where 210 ICT champions and approximately 20,000 teachers were trained on the integration of ICT in education. Furthermore, CEMASTE A trained 1500 master trainers who in turn trained 20,000 teachers on ICT integrated lesson plans (MOEST, 2014).

MOEST has also deployed ICT infrastructure to schools through projects such E-Schools initiative and the NEPAD e-schools. These projects have been coordinated and harmonized by MOEST and have guided the mobilization of ICT resources on partnerships between public and private sectors. Furthermore, partnerships with Global E-schools and Communities Initiative (GESCI), have seen schools benefit from Strengthening Innovation and Practice in Secondary Education Initiative (SIPSE) and African Digital Schools Initiative (ADSI). SIPSE pilot project helped enhance teacher capacity in the use of ICT in STEM subjects through blended learning technologies. It also acted as a bench march for ICT classroom practice and teacher development, technology, pedagogy and content knowledge (TPACK) framework and ICT teacher Competency Framework for Teachers (ICT-CFT) (Hooker, 2017).

GESCI developed the SIPSE pilot program into ADSI where each of the 20 schools received 5 laptops, 2 projectors and modems. This project has been implemented in three crucial cycles which include: technology literacy, knowledge deepening and knowledge creation. Hooker (2017) notes that the ADSI project is an upscale of the SIPSE with strengthened institutionalization components and a well-built leadership capacity for the planning and development of whole-school integration of ICT geared to the creation of Digital Schools of Distinction.

Despite the huge effort made to develop digital content and integrate ICT in the Kenyan curriculum, a huge gap exists in the availability of digital content. KICD has placed a lot of emphasis in the digitization of science content, but face limited financial, human and technical capacity to vet digital content (MOEST, 2014). In addition to this, teaching and learning through the use of ICT tools is a new phenomenon in the educational sector that requires huge investments in pre-service and in-service capacity building. Effective ICT integration has been a challenge to most schools because of limited financial resources, high staff numbers and inadequate ICT infrastructure due to vandalism, poor maintenance, theft of computers and accessories. Above all, inadequate monitoring and evaluation of ICT in education initiatives in schools is a main impediment in the integration of ICTs in teaching and learning because their effectiveness and contribution to the teaching and learning process is never assessed (MOEST, 2014).

## **II. METHODOLOGY**

### **Research Design**

The study employed a descriptive research design. This design involves information collection through questionnaire administration to sampled individuals. This method was chosen because the study was aimed at collecting the opinions and attitudes of the people on the impact that ADSI has made in STEM teaching in Narok county. All the participants were issued with questionnaires and asked to fill in their responses to the provided statements.

### **Sample and Sampling Procedure**

The participants of the study were purposively sampled because Cohen, Manion and Morrison (2007) note that purposive sampling is centred on people with an in-depth knowledge on certain issues because of expertise, access to knowledge, or experience. The primary group of knowledge people was 60 ADSI teachers from 20 selected schools who are engaged in the ADSI project. The study adopted a purposive sampling process in the selection of the participants from the 20 ADSI schools in Narok county. According to Cohen, Manion and Morrison (2007), purposive sampling is crucial for researchers because the cases in the sample are handpicked based on the possession of specific characteristics. The purposive sampling was confined to schools in the ADSI project in Narok County only. These schools were selected because they have functional computer laboratories and adequate teachers for STEM subjects.

### **Data Collection Instrument**

A questionnaire was used in gathering information from

teachers on the use of ICT in education and the perception of the learners towards ICT in teaching and learning. The questionnaire consisted of statements on teacher training on the use of ICT tools, the attitudes and knowledge of the learners and the ICT integration levels of the teachers. The items in the questionnaire were developed and designed by the researcher and were in line with the objectives of the study and provided the required responses. In the first objective, the participants were asked to read the given statements and respond to them based on 4-Linkert scale as follows: 1= Strongly Disagree, 2= Disagree, 3= Agree and 4= Strongly Agree.

**Findings**

**1. The impact of teacher training on the use of ICT tools.**

The professional development of teachers is a strategic aspect to a fruitful integration of computers in classroom teaching. In the ADSI project, STEM teachers are trained at the beginning of every cycle. The sampled teachers were asked about the impact of the training on the use of ICT instructional tools and materials on learners as indicated in table 1.

Looking at the responses of the teachers, it is evident that 61.7% of the teachers agreed and 31.6% strongly agree that the training impacted on their use of ICT in the classroom. This indicates that teachers view ICT in teaching and learning as a positive process where ICT acts as the missing link that teachers require in ensuring an effective teaching and learning. Despite this, 4.99% disagreed while 1.7% strongly disagreed as they were not able to easily and openly use ICT in their STEM lessons. These groups were unwilling to learn the use of ICT instructional tools and subsequently fail to integrate ICT in the process of teaching and learning. This is in line with Chigona and Chigona (2010) position that teachers who are not confident in technology use are less likely to incorporate it in their pedagogy.

From the obtained data, it indicates that the use of ICT in teaching has enabled the teachers to offer teaching in a better way. From the overall sample, most of the respondents strongly agreed to teaching better with ICT (75.5%) followed by those who agreed (21.6%), while 4.99% disagreed and disagreed strongly (1.7%) as they still trust the convection method of teaching. The competency and familiarity of the teacher in handling ICT has led to better teaching because of confidence in learning new computer skills which allows them to search teaching resources and materials from the internet. Given such a context, STEM teachers strongly agreed (43.5%) and agreed (49.9%) that they are able to prepare own ICT-based lessons. This, according to Ghavifekr & Rosdy (2015), is attributed to teachers who are open to ICT use in teaching, feel comfortable and are not resistant to new ideas in the teaching and learning process.

On the contrary, 4.99% and 1.7% disagreed and disagreed strongly to this and believe that they still achieve effective teaching without the use of ICT. These teachers reported a negative attitude towards the use of computers in classroom with those who disagreed having 6.3% while 1.7% strongly disagreed on the change of attitude towards ICT-based lessons. ICT lessons are crucial in pedagogical enhancement

as they demonstrate evidence of exemplary materials and emerging good practices by the teacher. This supports an interactive teaching and learning and promotes the acquisition of STEM subject concepts and content which is corroborated by Mwanda, Mwanda, Midigo & Maundu (2017). In light with this, most teachers strongly agreed (63.4%) and agreed (19.9%) that ADSI teacher training enabled them to acquire enhanced pedagogical practice while 13.4% disagreed and 3.3% strongly disagreed.

**Table 1: Impact of teacher training on ICT use in teaching and learning**

	Strongly agree	Agree	Disagree	Strongly disagree
Easily and openly use ICT in teaching and learning	19 (31.6%)	37 (61.7%)	3(4.99%)	1 (1.7%)
I can teach better through ICT	45 (75.5%)	12 (21.6%)	1 (1.70%)	1 (1.70%)
I prepare own ICT lessons	26 (43.5%)	30 (49.9%)	3 (5.0%)	1 (1.70%)
I have a positive attitude towards using computers in classroom	35 (58.0%)	21 (34.0%)	4 (6.3%)	1 (1.70%)
Enhanced pedagogical practice	38 (63.4%)	12(19.9%)	8 (13.4%)	2 (3.3%)

**2. The learners’ STEM comprehension levels, attitudes and knowledge towards STEM subjects.**

The researcher sought to ascertain the comprehension levels, attitudes and knowledge of the learners in STEM subjects. Linkert-type set of questions were presented to the teachers and were required to respond them and indicate the levels of agreements with the statements. The findings are presented in the table 2. The improvement in STEM subjects was informally assessed where most teachers agreed that the use of ICT in a STEM classroom provides the learners with opportunities for the improvement of their performance with 59.98% agreeing this to a greater degree and 34.99% entirely. Only 5.03% believe that ICT does not have any impact on the improvement of performance in STEM. It was also observed that ICT enhanced the desire for ICT integrated lesson as 83.3% of the participants entirely agreed this while 15% believed to a greater degree and 1.7% do not see ICT input in the desire for integrated lessons. ICT integration requires a successful strategic expansion and planning of support systems in schools. This contributes to the development of knowledge and higher order skills in the preparation of the learners for the attainment of digital knowledge.

Furthermore, 41.7% of the participants believed that learners are able to develop and practice higher order skills entirely and 53.3% to a greater degree which enhances learner comprehension levels, their attitudes and knowledge in STEM. This is contributed by the teachers who use computer in the classroom as a tool to find content from the internet (Adegbenro, Gumbo & Olakanmi, 2017). This provides the teacher with methodologies that facilitate the learner with the development of information literacy skills. Lastly, most of the teachers realized an increase in the STEM subject enrolment in an ICT-based lessons. The participants who reported an increase in STEM enrolment to a greater degree are 70.03%, 25.4% entirely and 8.3% saw no apparent improvement in enrolment despite the use of ICT in classroom teaching and learning. The increase in enrolment is attributed to the use of ICT which has actively engaged learners in the teaching, made them familiar with ICT hence find it easy to learner



concepts as opposed to traditional learning (Ghavifekr & Rosdy, 2015).

**Table 2: Learner STEM comprehension levels, attitude and knowledge**

ICT has enabled my learners to:	Entirely	To a greater degree	Not at all
Improve performance in in STEM subjects	21 (34.99%)	36(59.98%)	3(5.03%)
Enhanced desire for ICT-based lessons	50 (83.3%)	9(15%)	1(1.70%)
Practice higher order skills	32 (53.3%)	25 (41.70%)	3 (5.0%)
High enrolment in STEM subjects	15 (25.4%)	42 (70.3%)	5 (8.3%)

**3. The impact of ICT learning strategies such as simulations, concept mapping, webquests, infographics and open education resources (OERs) on STEM subjects among the learners.**

In order to ascertain the impact of ADSI ICT learning strategies on the learners, the respondents were asked to respond to the items in table 3 using Linkert scales given as ‘entirely’, ‘to a great degree’ and ‘not at all’. The participants were trained on these strategies at the beginning of every ADSI cycle in order to enhance technology literacy, knowledge deepening and knowledge creation competencies in STEM teaching and learning through an interactive blended learning model.

Majority of the teachers 59.97% reported that learning strategies have allowed the students to learn new and different things which they were not aware of before ADSI project was initiated. 33.33% of teachers believed entirely and 58.32% to a greater degree that ADSI ICT learning strategies enabled the learners in the development of new skills of interaction with other students and were able to comprehend the significance of collaboration in a STEM classroom. After the learners were taught using web quests and infographics, they created an infographic and a web quest using a computer tool, an assignment which enhanced peer collaboration. Because of these tasks, the teachers reported that learner participation and attention in the classroom were transformed entirely (53.32%) and to a greater degree (41.65%). Only 5.02% of the sampled teachers believed that the learning strategies did not transform the learners’ participation and attention.

The findings also indicated that ICT learning strategies that the teachers applied led to a simplified learning as they were able to learn abstract things entirely (66.7%), to a greater degree (30%) and only a 3.3% of the teachers indicated that there was no change at all as indicated.

**Learning of abstract things among learners**

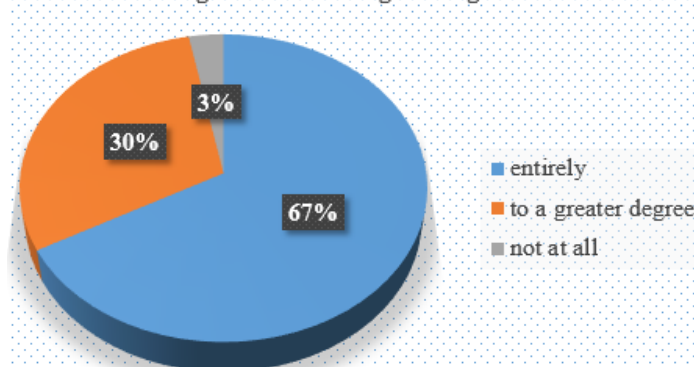


Figure 1: How ICT learning strategies have enabled the

learning of abstract content.

(Source: Researcher)

From table 3, the impact of ICT learning strategies on a friendly teaching and learning environment has been generated. The respondents agreed entirely (86.66%) and to a greater degree (13.34%) that ICT learning strategies resulted in a conducive environment. None of the sampled teachers reported that ICT learning strategies does not contribute to a friendly teaching and learning environment. This means that the learners are able to learn and grow content in a classroom teaching integrated with ICT tools. In addition, the teachers believed that the ICT skills and knowledge of the learners are sharpened entirely (36.65%), to a greater degree (56.64%) and only 6.66% saw the inefficiency of a technology integrated classroom in instilling skills in learners.

It was interesting to note that the use of ICT learning strategies impacts positively on the learner enthusiasm, interest and creativity. 66.64% of the sampled teachers reported a rise in learner enthusiasm, interest and creativity to a greater degree while 30% entirely noted the rise. Only 3.33% of the teachers do not believe that ICT learning strategies assist in boosting the interest of the learners. This finding is represented in the figure below:

**Increase in learner enthusiasm, creativity and interest**

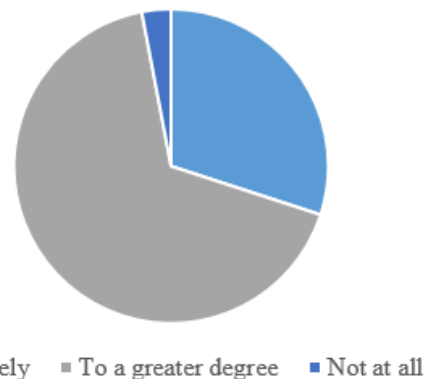


Figure 2. Increase enthusiasm, interest and creativity. (Source: Researcher)

**Table 3: The impact of ICT learning strategies on STEM subjects among the learners**

ICT has enabled my learners to:	Entirely	To a greater degree	Not at all
Learn new and different things	36 (59.97%)	21(34.98%)	3 (5.05%)
Develop of new skills of interaction	20 (33.33%)	35 (58.32%)	5 (8.34%)
Transform participation and attention	32 (53.32%)	25 (41.65%)	3 (5.02%)
Learn abstract things	40 (66.7%)	18 (30%)	2 (3.3%)
Friendly teaching and learning environment	52 (86.66%)	8 (13.34%)	0 (0%)
Sharpen ICT skills and knowledge	22 (36.65%)	34 (56.64%)	4 (6.66%)
Increase enthusiasm, interest and creativity	18 (30%)	40 (66.64%)	2 (3.33%)

**III. DISCUSSION**

This study reports the findings of effectiveness of ICT integration in STEM teaching and learning in ADSI schools. Looking at the report from the teachers, the statements given to the participants enabled the researcher to investigate the impact of teacher training on the use of ICT tools among teachers, the learner STEM comprehension level, attitudes

and knowledge as well as the impact of ICT learning strategies on STEM subjects.

The results of this study show that the training of teachers by ADSI for STEM-based ICT lessons is effective in comparison to the traditional method because it enabled the teachers to openly use ICT in classroom in teaching and learning hence made them to become better teachers. Additionally, ADSI STEM face-to-face training and participation in online chats and discussion forums enhanced teachers with skills and effective ways of preparing own lesson through the use of images, simulations and learning software such as VUE and eXe learning. This is in line with Padmavathi (2013) who posit that customized training courses for teachers result in enhanced technical and pedagogical skills in integrating technology in learning. The trainings allowed the teacher to use computer which facilitated effective pedagogical practice and change of attitude towards the integration of ICT in STEM teaching and learning. The workshop expanded the computer knowledge and skills of the teacher which cascades down to the learner. Several studies such as Sánchez, Marcos and GuanLin (2012) and Padmavathi (2013) have investigated the connection between attitudes in the use of ICT and the comprehension levels in STEM subjects. For instance, Padmavathi (2013) found a positive attitude in ICT transformative role which offers an opportunity for the instructor to enhance the motivation and attention of the learner. Results of the present study indicate an improved performance in STEM because of the enhanced desire for ICT-based lessons with enriched content and practice of higher order skills. This is corroborated by Ghavifekr & Rosdy (2015) who argue that ICT integrated lesson foster learning because it becomes interesting and engaging hence a notable enrolment in STEM subjects.

Lastly, ICT learning strategies such as the use of simulations, webquests, infographics and concept mapping are crucial in effective teaching and learning. The findings from the study have shown that these strategies have led to easy learning of abstract content, transformed participation, sharpened ICT skills and increase in learner enthusiasm, interest and creativity. Ghavifekr et.al (2014) attributes these to the engagement of the students in interactive tasks which offer a wider range of knowledge and information during inquiry-based and project-based learning.

### Conclusion

The study concludes that ADSI teacher training instilled ICT skills and knowledge to the teacher which cascades down to the learners who interact with ICT tools thus stimulated learning. Also, the teachers are able to maturely use ICT learning strategies in STEM teaching and learning. In the sampled schools, it was established that the use of ICT as a teaching and learning tool instilled 21<sup>st</sup> century skills on learners, improved learning outcomes and led to incorporation of ICT-based learning opportunities to improve the quality of learning in STEM. Additionally, the findings indicate that a successful use of technology-based teaching and learning is largely due to well-resourced teachers in lesson preparation using ICT tools which critically enhanced quality learning among the learners.

### IV. RECOMMENDATIONS

Because of the success of the ADSI model in teaching and learning in the sampled schools, the study recommends the following:

- a) A formulation of clear policies that will guide a strategic partnership between the Government of Kenya, MOEST, KICD and other NGOs to step up efforts in ICT training of all teachers, implementation of ICT in teaching and learning and the provision of adequate ICT infrastructure in all schools.
- b) Formulation of policies and consider the need for other ICT integration aspects particularly from the management point of view regarding policy making and strategic planning.
- c) Universities and colleges which offer teacher training programs should consider training teachers on the integration of ICT in teaching and learning in their programs.

### V. IMPLICATIONS

The findings of this research are crucial for policy implementation. With the use of ICT in teaching and learning, the students and teachers will be able to source primary materials from the internet and develop interpretative skills. ICT will enable teachers to effectively teach hard concepts, introduce better ways of learning and teaching which will impact positively on the process skills, motivation and communication among the learners.

Use

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**Teaching and Learning with Technology: Effectiveness of ICT Integration in Science, Technology, English and Mathematics (STEM) Teaching and Learning in African Digital Schools Initiative (ADSI) Schools in Narok County**

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