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Adequacy of STEM Resources and Academic Achievement in STEM Subjects: Case of Selected Secondary Schools in Western Kenya

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

This paper presents part of the preliminary findings of a baseline survey for "Project Impact: Empowering East African Students in STEM Education" research project. Grounded in a mixed method research approach, this baseline study sought to investigate the relationship between STEM resources and academic achievement in STEM subjects in selected schools in Western Kenya. Four objectives guiding the study were: To explore the status of adequacy of STEM resources in selected schools; to examine the trend in STEM subjects KCSE performance in the last five years (2015-2019); to determine the relationship between adequacy of STEM resources and academic achievement and to determine the challenges and opportunities faced in STEM teaching and learning. A sample of 12 schools were selected from three counties in Western Kenya. Through purposive sampling, 12 principals, 12 deputy principals, and 48 teachers of physics, chemistry, biology and mathematics were selected. Data were collected using questionnaires, document analysis, observation checklist and structured interviews. The primary purpose of the baseline data collection was to understand the status of selected schools with respect to performance in STEM subjects. The data collected will form a basis for the implementation of the project if it is funded. Quantitative data were analysed both descriptively using means and inferentially through simple linear regression. Qualitative data were transcribed, coded, and presented as emergent themes. Three emergent themes from the interviews were: inadequate STEM resources and infrastructure necessary for effective teaching of STEM subjects, teacher-centred techniques of teaching and negative attitudes towards the subjects. From

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observation data, it was evident that there was acute shortage of appropriate physical resources, especially text books and laboratory equipment. Three out of the twelve schools lacked science laboratories. Classrooms were improvised to store the scarce equipment and apparatus. The average mean score for KCSE in all the twelve sampled schools was $\bar{X} = 4.373$, a score below the pass mark of 6.000 and therefore did not qualify to transit to the university. However, results of simple linear regression revealed no statistically significant relationship between adequacy of STEM resources and academic achievement ($F(1,47)= 2.168$; $t = -1.472$; $\beta = -0.212$; $p = 0.148$). This was an interesting finding that requires further investigation considering the small sample of schools. The study concluded that requisite resources and appropriate instructional techniques were critical in enhancing students' academic performance in STEM subjects. It was recommended that innovative pedagogical practices such as integration of technology in teaching and learning was inevitable. Capacity building for in-service STEM teachers was recommended and expansion of school STEM infrastructure was an additional recommendation. These findings have implications for implementation of Project Impact, if funded and further research.

Keywords: Adequacy; infrastructure; resources; STEM; technology.

1. INTRODUCTION

Globally, strengthening Science, Technology, Engineering and Mathematics (STEM) education is recognized as embedding solutions to many societal problems like the depletion of natural resources and issues related to climate change. Recognising that STEM education program is expected to create a culture that inspires learners to excel and pursue careers related to science and mathematics, engaging students in active leaning focused on fostering STEM competencies is vital for students' future employment prospects [1-3]. According to Ferrini-Mundy [4], more hands-on, authentic STEM activities should be provided at the secondary level. There is a host of research regarding the importance of resources in the teaching and learning process [5-18].

In Education, learning and instructional resources are important. They are the primary means through which students gain access to knowledge and skills. Textbooks, instructional materials, equipment, and technology are essential tools in educational system, and they must be provided to all learners [19, 20, 21, 22, 6]. Lack of these teaching and learning resources poses a challenge in the teaching processes. According to Harris [23] shortage of teaching and learning materials leave learners with less knowledge about a subject as compared to those who have adequate resources hence affects negatively the teaching process. Many schools' performance in mathematics and science is either low or average making it necessary to address factors that could be contributing to the poor performance. Factors contributing to students' performance in mathematics and science in Kenyan secondary schools are known and well documented as under-staffing, inadequate teaching and learning resources, poor attitudes to both teachers and students, lack of role models among others [24].

According to Ojuok, J. O., Gogo, J. O., and Olel, M. A. [25], good and adequate physical facilities will ensure learning environment is learner-friendly and will make teaching and learning enjoyable to both the teacher and the learner. Dilapidated buildings, and in extreme cases, lack of essential buildings like laboratory, library, computer rooms, classrooms and even offices inhibit learning and this leads to poor performance by the students. science laboratories, classrooms and computer laboratories are significant factors that influence performance of students in sciences. Mang'eni G. Nasambu [26] investigated influence of availability of equipment, learning aids and facilities on the practical skill abilities of the learners in physics during classroom interaction in selected schools in Sirisia Division, Bungoma West Sub-County, Kenya. Findings revealed that availability of equipment, teaching aids and other facilities are necessary for learners to develop practical physics skills

The wide gap between demand and supply of STEM related skills in Kenya are the reason behind the current study. The main objective was to explore the current status of STEM resources in terms of availability, adequacy, maintenance and usage, and how they impact on academic performance in STEM subjects.

1.1 Research Objectives

This study sought to answer three research objectives:

1. To explore the status and availability of STEM resources in selected schools
2. To examine the trend in STEM subjects KCSE performance in the last five years (2015-2019)
3. To determine the relationship between availability of STEM resources and academic achievement
4. To determine the challenges and opportunities faced in STEM teaching and learning

1.2 Problem Overview

Globally, strengthening Science, Technology, Engineering and Mathematics (STEM) education is recognized as embedding solutions to many societal problems like the depletion of natural resources and issues related to climate change. Despite the fact that STEM subjects play an important role in the development of the scientific base necessary to become industrialized as envisaged in Kenya's Vision 2030 (Government of Kenya [27] Kenya Vision 2030), the students' performance in these subjects has been on the downward trend in recent years as evidenced in Kenya Certificate of Secondary Education (KCSE) results in the last five years . Innumerable efforts in trying to improve the performance of science subjects have been witnessed in the last decade. In Kenya, the wide gap between demand and supply of STEM related skills are the reason behind the launch in 2016 of 47 model schools (one in every County), whose main goal was to nurture students to become 'effective lifelong learners equipped with appropriate knowledge, generic skills as well as values and attitude, necessary for facing challenges in the 21st century' [28]. However, there is still public outcry and growing concern about the falling standard of STEM education specifically which can be attributed to many factors such as unavailability of instructional facilities in public schools, unavailability of laboratories, libraries, science instructional materials, dilapidated structures, etc [29]. Teaching resources in STEM promote effectiveness in teaching and translate to improve academic performance.

It is on this note that this study was carried out to ascertain the the trend in KCSe performance in selected schools and to understand the relationship between resource adequacy and performance in STEM subjects

2. LITERATURE REVIEW

2.1 STEM infrastructure

School infrastructure is critical for learning in educational institutions. School infrastructure includes and not limited to classrooms, laboratories, libraries, school halls, dormitories, sanitation facilities, and open fields for games and sports. Day to day formal teaching and learning takes place in the classrooms. In the libraries, learners get the opportunity to conduct their own personal studies and carry out research. It is in the field that co-curriculum activities take place. Learners and teachers need to be housed in the school and at the same time need sanitation facilities like toilets, waste disposal services and clean water. School infrastructure is therefore a very important component in ensuring successful education. Usman [30] noted that central to the education process are educational resources which play an important role in the achievement of education objectives and goals by enhancing effective teaching and learning.

According to Adeogun and Osifila [31] physical resources include laboratories, libraries, classrooms and a host of other physical infrastructure while material resources include textbooks, charts, maps among others. STEM infrastructure in this study focused mainly on Science laboratories, library, classroom, and Computer laboratories in terms of their adequacy and equipment.

2.2 Science Laboratories

The effect of using laboratories in teaching and learning of sciences and other science related disciplines cannot be underestated, as students tend to understand and recall what they see than what they hear or were told .The laboratory is essential to the teaching of sciences and the success of any science course is much dependent on the laboratory provision made for it. Laboratory experimentation that allows students to explore and apply science through hands-on experience is considered central to science education [32, 33, 34]. However, physical equipment for science and technology is expensive to purchase and maintain for individual schools [32].

Logistical constraints, particularly funding difficulties, place huge limitations on schools' capacities to maintain students' interest and engagement in learning science-related subjects [32,35]. It is argued that in order to engage more students to learn STEM, they need to access STEM experiences more often and more effectively. Hence, schools need to provide equipment for students to learn STEM and teachers need to be prepared to teach STEM. Access to equipment and professional development will ensure that teachers can provide motivating and engaging lessons for students to learn STEM. Affirming this Ogunniyi [36] said that there is a general consensus among science educators that the laboratory occupies a central position in science instruction. The success of any science course is much dependent on the laboratory provision made for it. In most Kenyan secondary schools, biology and chemistry are compulsory subjects, with physics being left as elective. This implies the need for three science and subject-specific laboratories (biology, chemistry, and physics). Group seven of subjects in Kenyan curriculum are the technical subjects which include mechanical, electrical engineering and computer studies. These subjects require laboratories and workshops too. Apart from laboratories, a library is very critical in promoting academic performance.

2.3 Libraries

School libraries help to inculcate a culture of lifelong learning among students [37]. A school library is defined as a library in a public or private elementary or secondary school that serves the information needs of its students and the curriculum needs of its teachers and staff, and is usually managed by a school librarian or media specialist. Libraries can play an active role in teacher research and enhancing student understanding of science. Libraries build connections between student information/ research needs, curriculum content, learning outcomes, and information resources as they support the overall educational community in the school [16]. Despite these unique characteristics of school libraries, there has been little discussion about utilising library resources to promote STEM leaning and innovation. Despite the tremendous interest and energy surrounding young people and STEM education, the role of school libraries in these initiatives is rarely examined. A deep engagement in STEM requires much more than memorizing isolated facts or information. Pursuing STEM interests also requires scientific literacies that are embedded in talking, reading, viewing, and doing science. A vital question to answer is how to engage underrepresented young people in STEM and help them persist in these fields as they progress through their education and professional trajectories. There is a tremendous opportunity to both communicate the potential ways that school libraries can promote innovation in STEM education and develop research that collects evidence of these innovations. School librarians have only recently begun voicing their potential roles in enhancing STEM learning (Balack, L., 2009; Fries-Gaither, 2010; Mardis, M., and Howe, K., 2010; McIlvain, E.,2010; Schultz-Jones, Barbara,2010). While formal science classrooms may be constrained in their use of technology, school libraries can promote youth participation in technology and online communities that may enhance their STEM learning.

In teaching and learning of Science and mathematics, besides physical resources, there is need for learning materials. These include among others; text books, laboratory apparatus, materials and chemicals, (Science Equipment and apparatus), charts, models, realia, etc.

2.4 Text Books

A study by Altbach [38] noted that nothing has ever replaced the printed word as the key element in the educational process and as a result textbooks are central to schooling at all levels. According to Owoeye and Yara [8], in some instances textbooks provide the only source of information for students as well as the course of studies for the subjects Squire [39] writing on teachers reliance on textbooks stated that those seeking to improve the quality of education in instructional materials would inevitably lead to changes in actual teaching. While the selection of a textbook has been judged to be of vital importance to academic achievement, it is sad to say that relevant books are not available for teaching and learning activities. According to Odulaja and Ogunwemimo [40], lack of textbooks could be identified with high cost. Since the educational process functions in a world of books according to Owoeye and Yara [8], the chief purpose of a school library is to make available to the pupil at his or her easy convenience all books, periodicals and other reproduced materials which are of interest and value which are not provided

as basic or supplementary textbooks. They further noted that as a resource the library occupies a central and primary place in any school system as it supports all functions of the school. According to Fowowe [41] a library must be up to date and at the same time allow access to older materials. While the selection of a textbook has been judged to be of vital importance to academic achievement, it is sad to say that relevant books are not available for teaching and learning activities. In Kenya, the Government through the Ministry of Education, Science and Technology (MOEST) provides text books to schools. However, there has been an outcry about the quality of the books in terms of content where STEM teachers lament that most of the books do not have enough content and/or are laden with errors. It may be necessary to combine text books with other teaching and learning materials.

2.5 Other Teaching and Learning Materials

Before a teacher gets to class, he/she is required to choose the proper resources to use during the teaching process. Thus, choosing of teaching aids, which do not meet the learning needs of children, is another challenge facing the teaching of science and mathematics. This is despite the fact that there are many resources that teachers can choose to support the pupils learning. The materials are often inadequate and fail to give each child an opportunity to practice their various skills.

3. METHODS

3.1 Research Design

A mixed method research design was adopted in this study. Using mixed method research approach contributes to the depth and breadth of the study and helps overcome the weaknesses of both methods (Johnson & Onwuegbuzie, 2004). Moreover, integrating qualitative and quantitative methods produces better results in terms of quality and scope. This is based on the notion of triangulation and complementarily [42]. The quantitative component involved cross sectional descriptive survey design. According to Kothari [43] descriptive survey research design studies were designed to obtain pertinent and precise information concerning the current status, phenomenon and where possible to draw conclusions from the facts obtained. The qualitative component was phenomenological research design. According to Creswell, [44], phenomenology is an approach to qualitative research that focuses on commonality of a lived experience within a particular group. The fundamental goal of the approach is to arrive at a description of the nature of the particular phenomenon. Both qualitative and quantitative data were collected through questionnaires, observations, document analysis and interviews.

3.2 Study Location

This study was carried out in Kakamega, Vihiga and Kisumu Counties of Western Region in Kenya. In specific, the study was conducted in twelve (12) rural and semi-urban schools ensuring representation of the population. The justification for selection of the rural and semi-urban schools was guided by literature which indicated persistent dismal performance of students in STEM subjects.

3.3 Target Population

The target population comprised of STEM teachers, Deputy principals, Director of studies, and principals.

3.4 Sampling Procedures and Sample Size

Multi-stage sampling technique was adopted. 3 counties from Western Kenya were purposively selected. From each county, 4 schools were randomly selected through stratified random sampling using type of school as the stratum. So in total we had girls' only schools, boys' only schools and co-educational schools. STEM teachers (biology, chemistry, physics and mathematics), deputy principal and Director of studies from each school were purposively selected to participate in the study. In total there were 3 counties, 12 schools, 48 STEM teachers, 12 deputy principals and 12 Directors of studies.

3.5 Methods of Data Collection

Both Primary and secondary data were obtained in this study. In addition, both qualitative and quantitative data were collected. Four instruments were used: Face-to-face interviews, Questionnaires, Document analysis and Observation checklist.

3.5.1 Interviews

Interview sessions were held with the deputy school principals, Director of studies and STEM subject teachers to establish the following:

1. Types of STEM resources available
2. Usage of STEM resources
3. Academic performance in STEM subjects from 2015 to 2019

The interviews lasted between 30minutes to 1 hour, guided by an interview schedule.

3.5.2 Observations

On-site observations were made in the sampled schools regarding the state of school physical STEM resources and infrastructure, their adequacy, and maintenance.

3.5.3 Document analysis

School records were sought and recorded from the deputy principals concerning student enrolment by grade, gender and subject and, school staffing by subject, gender and employment status. The Director of studies provided data on school performance in national examinations by subject between the years 2015 and 2019.

3.6 Data Analysis and Presentation

Quantitative data were analysed both descriptively (means and percentages) and inferentially by simple linear regression. Graphs and tables were also used to present quantitative data.

Qualitative data were transcribed, coded and analyzed thematically. Emergent themes were generated.

4. RESULTS

Results are presented thematically by objective. Three objectives were tested.

4.1 Status and Availability of STEM Resources

Objective one: To explore the status and availability of STEM resources in selected schools.

School infrastructure has a great contribution towards transforming a school into a model school The current study purposed to investigate the status and availability of STEM resources in the selected schools. Findings are presented in Table 1.

Results in Table 1 indicate that in all the schools there were adequate classrooms for the number of streams available. With respect to science laboratories, 2 schools (17%) had 3 laboratories for each of the three science subjects (biology, chemistry and physics). Three schools (25%) had only 2 laboratories. The remaining seven schools (58%) had only 1 laboratory serving all the three subjects. The laboratories in most of the visited schools were in deplorable state and lacked basic apparatus. Fig. 1 presents a picture in one of the schools.

For libraries, three schools (25%) did not have a library at all. Four schools had improvised rooms that served as a library/ bookstores, while five had fairly stocked libraries. Fig. 2 shows a library-cum bookstore in one of the schools visited.

For computer laboratories, only 2 schools (17%) offer computer studies. They however lacked adequate infrastructure. In one school, they had 16 computers against 60 students who are taking computer studies. In another, there were 27 computers against 106 students.

Document analysis and observations revealed that the Government provides course books to schools. In most schools (8) they were enough, while in the remaining 4 schools they were inadequate. Teachers complained that they are not involved in choosing the publisher. They lamented that some text books had errors.

4.2 Students' Performance in STEM Subjects in National Examinations

The survey sought to establish the nature and trends in students' performance in KCSE between the years 2015 and 2019. The data were collected and analysed by school and subject of study. The findings are presented as follows:

4.2.1 Overall students performance

The average mean score in each of the twelve sampled schools was computed. Table 2 provides a summary of the findings.

Table 1. Status and availability of STEM resources

SN	School	No of laboratories		Libraries
		Science	Computer	
1	Bukhaywa Mixed	1	1	27
2	Ibinzo Girls	1	0	1
3	St. Lukes Shisango G	1	0	0
4	St. Paul's Ebusia	1	0	0
5	St. Paul's Erusui	2	1	17
6	Bukhulunya Mixed	2	1	16
7	Ebungangwe Boys	1	1	10
8	Ebusakami Girls	3	1	10
9	Ndiru Mixed	1	0	0
10	Kobura Girls	1	0	0
11	St.Benedict Nyangoma	1	1	0
12	Ayiecho Nyatao Mixed	1	0	0

Source: Filed Data

Fig. 1. Photo of a laboratory in one of the visited schools

Fig. 2. Photo of a Library in one of the schools visited

Table 2. Trends in Students Performance in KCSE by School

SN	School Name	Aggregate Mean Score	Mean score 2019	Mean score 2018	Mean score 2017	Mean score 2016	Mean score 2015
1	Bukhaywa Mixed	5.679	5.808	6.191	6.013	5.032	5.351
2	Ibinzo Girls		4.008	3.617	2.825	3.653	5.221
3	St. Lukes Shisango Girls		2.983	2.492	2.645	2.891	-
4	St. Paul's Ebusia Mixed		3.983	3.176	4.628	4.945	5.987
5	St. Paul's Erusui Girls		5.041	4.219	4.490	5.709	6.271
6	Bukhulunya Mixed		4.962	5.308	4.819	5.309	6.510
7	Ebungangwe Boys		4.888	3.983	4.321	3.532	4.958
8	Ebusakami Girls		5.312	4.977	4.651	5.652	6.434
9	Ndiru Mixed		4.279	3.570	3.690	4.049	5.488
10	Kobura Girls		3.104	2.407	2.806	2.808	3.963
11	St. Benedict Nyangoma Boys		4.335	3.347	3.276	4.293	4.819
12	Ayiecho Nyatao Mixed		4.028	3.906	3.991	4.363	4.308

Source: Field data

The findings in Table 2 reveal that the average mean score for all the twelve sampled schools was 4.373. This implies that the majority of students in the schools scored below the pass mark of 6.000 and therefore did not qualify to transit directly to the university. There was no major difference in overall student performance among schools of different types, girls schools (MS=4.037), boys schools (MS=4.336) and mixed schools (MS=4.659). However, students in mixed schools slightly outperformed their counterparts in boys' only and girls' only schools.

Analysis by subject revealed interesting results. Physics which is always perceived as a tough subject and difficult to pass showed better scores in most schools as illustrated in Fig. 4.

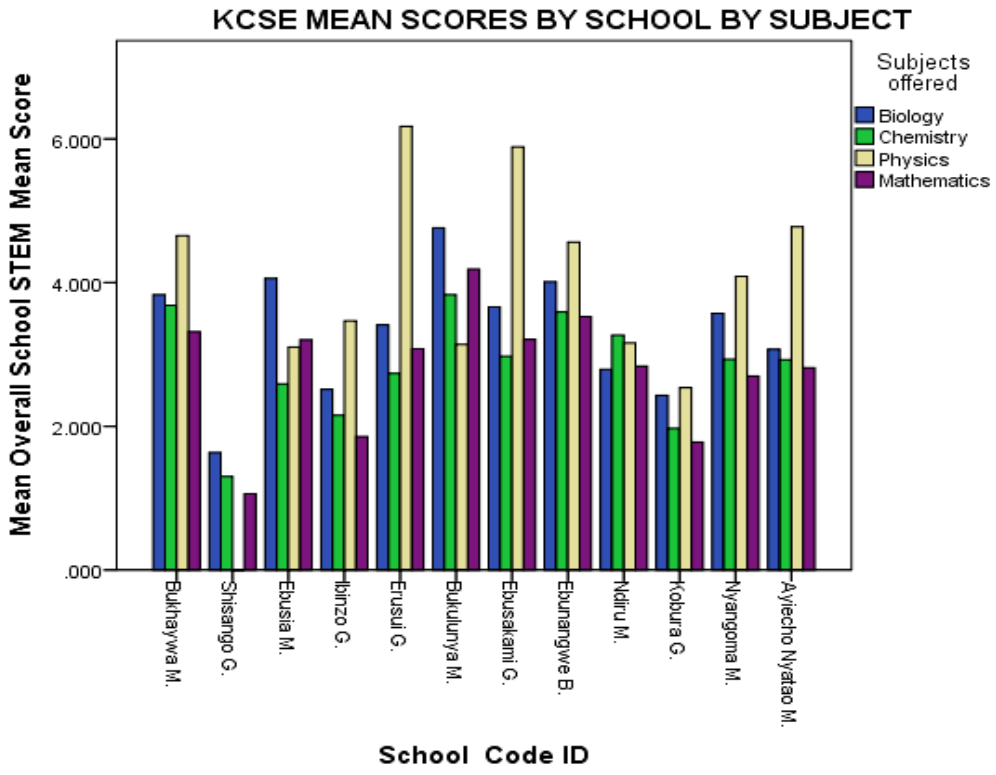

Fig. 3. KCSE Performance by Subjects

4.3 Students Performance in Mathematics

The average mean score in each of the twelve sampled schools was computed. The findings are presented in Table 3.

The findings in Table 3 reveal that the average mean for Mathematics was 2.767. It is important to note that a good score in Mathematics is a prerequisite to enrolling into any STEM programme of study at the university. With such dismal performance, students fail to pursue STEM-related programmes at tertiary levels. Average mean score in boys' only schools (MS= 2.604) was higher than their counterparts in girls' only schools (MS = 2.252). The findings suggest gender differences in achievements in Mathematics. Interestingly students in mixed day schools posted the highest mean score of 3.173.

4.4 Students Performance in Chemistry

The average mean score in each of the twelve sampled schools was computed. The findings are presented in Table 4.

The findings in Table 4 reveal that the average mean for Chemistry in the twelve sampled schools was 2.793. This is very dismal performance given that the maximum possible mean score is 12.00. This implies that an overwhelming majority of the students cannot transit and pursue STEM programmes that require foundation in Chemistry. It was also revealed that students in boys' only schools posted an average mean of 3.268 which was higher than their counterparts in girls' only schools at 2.417. The findings suggest gender differences in achievements in Chemistry subject in favour of boys.

Table 3. Trends in KCSE Performance in Mathematics by School

SN	School Name	Mean score 2019	Mean score 2018	Mean score 2017	Mean score 2016	Mean score 2015
1	Bukhaywa Mixed	4.374	3.693	3.297	1.713	3.500
2	Ibinzo Girls	1.967	2.236	1.870	1.360	1.845
3	St. Lukes Shisango Girls	1.270	1.590	1.230	1.220	-
4	St. Paul's Ebusia	2.952	2.467	3.393	3.510	3.707
5	St. Paul's Erusui Girls	3.865	2.447	3.130	2.777	3.177
6	Bukhulunya Mixed	4.940	4.710	4.160	3.638	3.500
7	Ebungangwe Boys	3.7727	2.700	3.684	1.550	2.480
8	Ebusakami Girls	4.000	3.456	3.394	3.145	3.637
9	Ndiru Mixed	2.84-	3.500	2.880	2.883	3.949
10	Kobura Girls	1.730	1.500	1.800	1.380	2.500
11	St. Benedict Nyangoma Mixed	3.406	2.295	3.148	2.050	2.608
12	Ayiecho Nyatao Mixed	3.0098	2.400	3.069	2.959	2.639

Source: Field Data

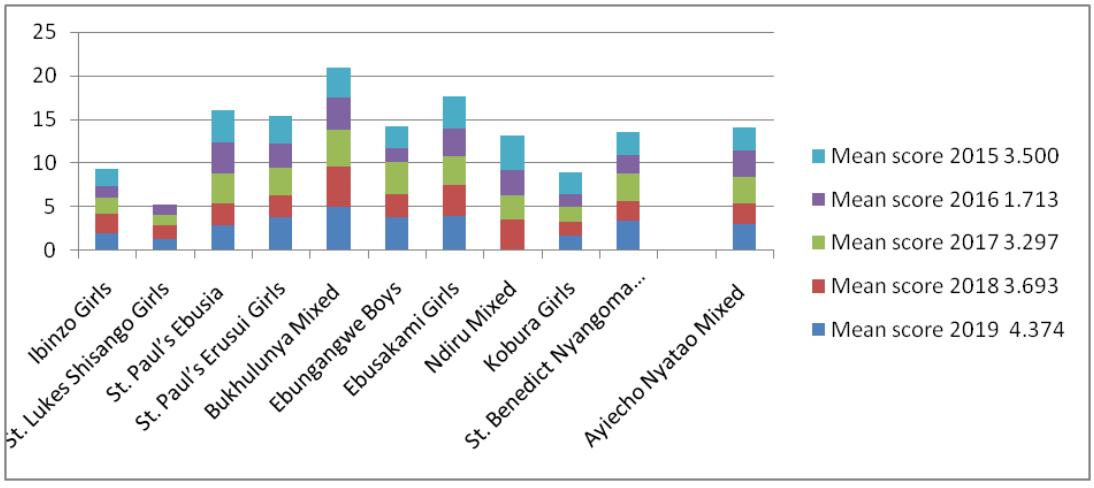

Fig. 4. Students Performance in Mathematics

Table 4. Trends in KCSE Performance in Chemistry by School

SN	School Name	Mean score 2019	Mean score 2018	Mean score 2017	Mean score 2016	Mean score 2015
1	Bukhaywa Mixed	3.861	3.891	3.187	2.931	4.548
2	Ibinzo Girls	2.246	2.222	1.790	1.950	2.568
3	St. Lukes Shisango Girls	1.680	1.410	1.420	2.000	-
4	St. Paul's Ebusia	2.798	2.619	2.238	2.765	2.533
5	St. Paul's Erusui Girls	2.434	2.250	2.342	2.474	4.177
6	Bukhulunya Mixed	2.440	3.150	2.200	2.846	4.660
7	Ebungangwe Boys	4.167	3.600	2.947	2.148	3.480
8	Ebusakami Girls	3.020	3.108	3.263	2.673	5.899
9	Ndiru Mixed	2.391	2.750	3.504	2.623	3.603
10	Kobura Girls	1.770	1.900	1.640	1.760	2.790
11	St. Benedict Nyangoma Mixed	2.766	3.016	2.574	2.225	4.078
12	Ayiecho Nyatao Mixed	2.627	2.637	3.023	2.429	3.918

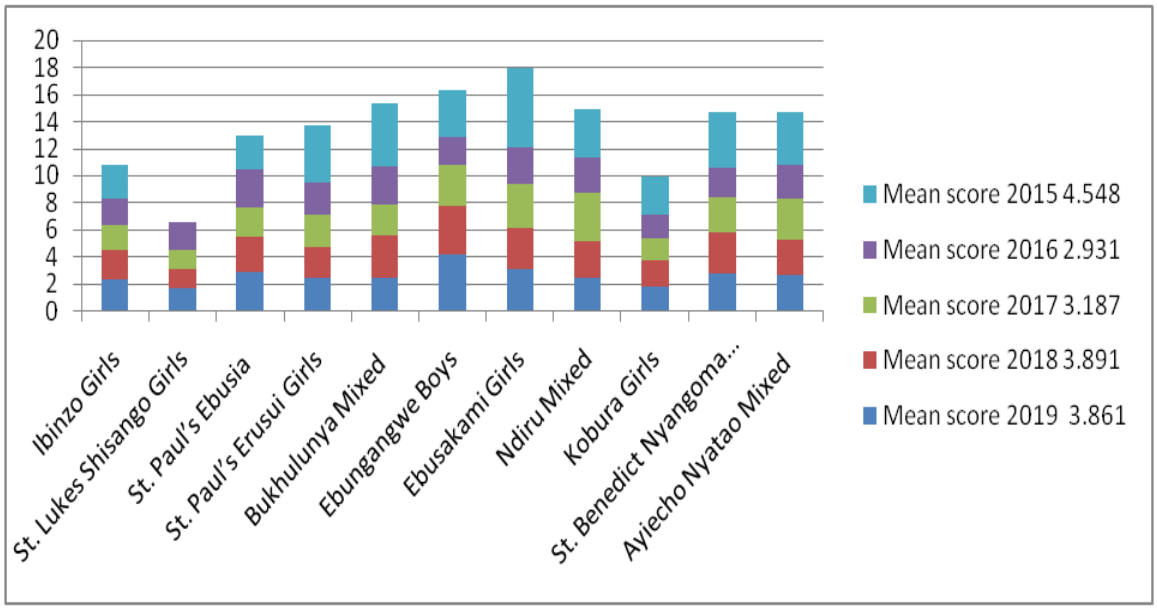

Fig 5. Trends in KCSE performance in chemistry by school

4.5 Students Performance in Biology

The average mean score in each of the twelve sampled schools was computed. The findings are presented in Table 5.

The findings in Table 5 reveal that the average mean for Biology in the twelve sampled schools was 3.074. This portrays dismal performance in the subject and the implication is that the majority of the students cannot transit to tertiary institutions and pursue STEM programmes that require foundation in Biology. Additionally, students in boys' only schools posted an average mean score (*MS*= 4.015), which was higher than their counterparts in girls' only schools (*MS*= 2.925). This suggests significant gender differences in academic achievement in Biology subject, in favour of boys.

4.6 Students Performance in Physics

The average mean score in each of the eleven schools that offer Physics was computed. The findings are presented in Table 6.

The findings in Table 6 reveal that the average mean for Physics in the twelve sampled schools was 4.328. This suggests that majority of the students who choose Physics end up not performing well in the subject. Furthermore, students in mixed schools posted the highest

score (MS= 4.763), followed by those in girls' only schools (MS= 3.996) while students in boys' only schools recorded the least mean score of 3.159.

Table 5. Trends in KCSE Performance in Biology by School

SN	School Name	Mean score 2019	Mean score 2018	Mean score 2017	Mean score 2016	Mean score 2015
1.	Ibinzo Girls	2.705	2.440	1.670	2.455	3.310
2.	Bukhaywa Mixed	4.096	3.653	2.714	3.046	5.655
3.	St. Lukes Shisango Girls	2.550	1.940	1.460	2.220	-
4.	St. Paul's Ebusia	3.183	2.886	3.197	5.020	6.011
5.	St. Paul's Erusui Girls	2.989	2.742	2.270	4.231	4.835
6.	Bukhulunya Mixed	2.970	3.700	2.570	4.000	5.920
7.	Ebungangwe Boys	3.985	3.300	2.842	3.666	6.260
8.	Ebusakami Girls	3.237	2.709	2.544	3.145	6.667
9.	Ndiru Mixed	2.992	2.636	2.111	3.078	5.885
10.	Kobura Girls	2.470	1.640	1.440	2.070	4.540
11.	St. Benedict Nyangoma Mixed	3.531	2.246	2.213	3.325	6.549
12.	Ayiecho Nyatao Mixed	3.1274	3.225	2.169	3.061	3.787

Source: Field data

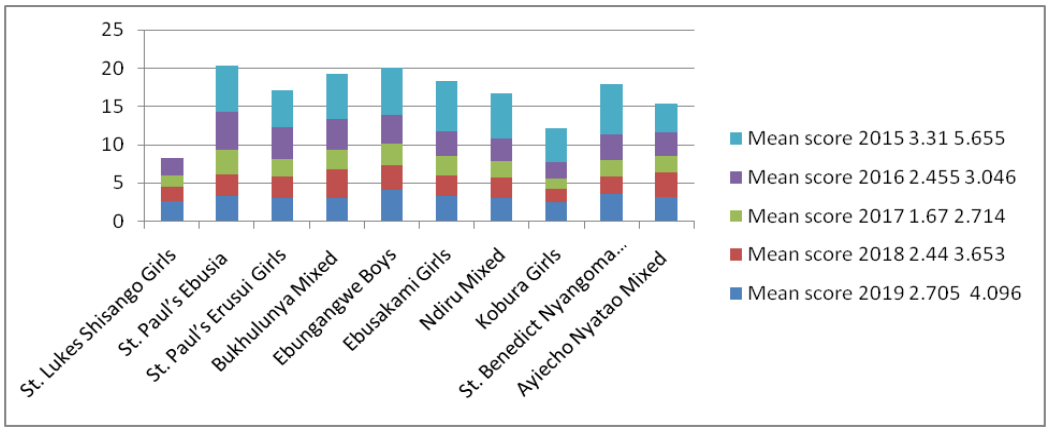

Fig. 6. Students performance in biology

Table 6. Trends in KCSE performance in physics by school

SN	School Name	Mean score 2019	Mean score 2018	Mean score 2017	Mean score 2016	Mean score 2015
1	Bukhaywa Mixed	5.900	5.737	4.211	2.696	4.727
2	Ibinzo Girls	3.800	3.100	2.300	3.142	5.000
3	St. Lukes Shisango Girls	-	-	-	-	-
4	St. Paul's Ebusia	2.590	2.391	`2.667	3.875	4.000
5	St. Paul's Erusui Girls	3.882	3.923	5.333	8.667	5.263
6	Bukhulunya Mixed	5.440	5.440	5.500	6.250	6.630
7	Ebungangwe Boys	3.619	2.900	2.500	3.444	3.330
8	Ebusakami Girls	3.216	3.672	4.957	6.700	4.269
9	Ndiru Mixed	5.259	4.217	6.412	7.889	5.667
10	Kobura Girls	2.330	2.200	2.500	2.000	3.660
11	St. Benedict Nyangoma Mixed	4.154	3.412	3.349	5.182	4.333
12	Ayiecho Nyatao Mixed	4.158	5.000	5.500	6.143	3.080

Source: Field data

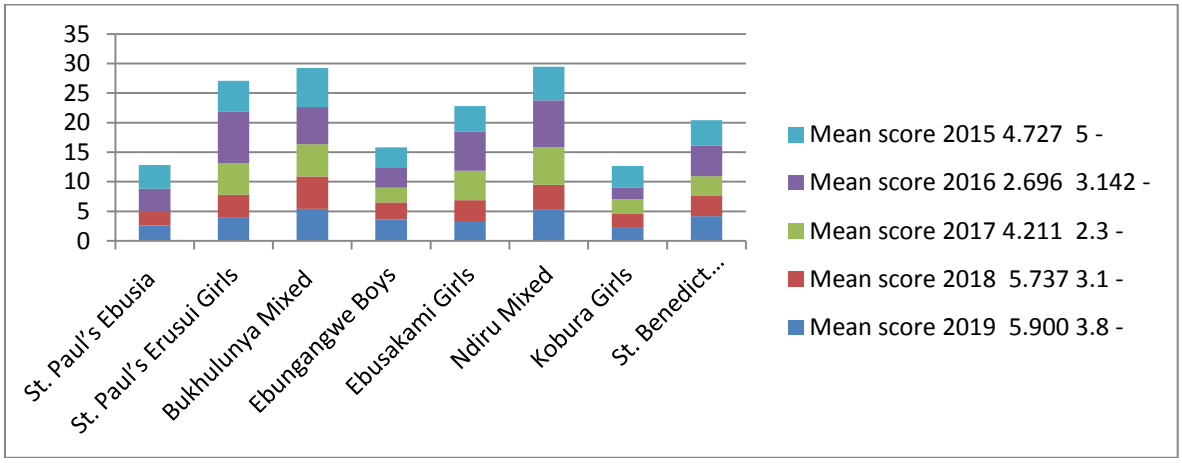

Fig. 7. Students Performance in Physics

5. CHALLENGES ENCOUNTERED IN TEACHING AND LEARNING OF ENGLISH AND STEM SUBJECTS

5.1 Introduction

The survey sought to establish the challenges encountered in teaching and learning of STEM and English subjects in sampled schools. Data for this section was gathered by way of observations and interviews with subject teachers and school administrators. A total of 6 subjects were considered: English and 5 STEM subjects of Mathematics, Biology, Physics, Computer Studies and Chemistry. Among these subjects, English, Biology, Mathematics and Chemistry are compulsory subjects and are therefore taken by all students. Physics and Computer Studies are optional subjects and students can drop them in Form II. However, in Form one, all students take their studies in all the subjects. The challenges are discussed by subject. For each subject, the order of the challenges is by the most significant. Having considered all the challenges across subjects, they have been aggregated into:

a) School related challenges
b) Teacher related challenges
c) Student related Challenges

The following is now a description of the challenges per subject:

5.2 Challenges with Respect to Mathematics Subject

The study revealed that students' academic achievement in mathematics subject was hampered by a myriad of challenges. The challenges are presented systematically under the following three themes: Student related challenges; school related challenges; and teacher related challenges. Study findings on the listed themes are presented hereunder:

5.2.1 Student related challenges

Interview data indicate that the major student related challenges encountered in the sampled schools were negative attitude towards mathematics and low entry behaviour. In specific, negative student attitude towards mathematics was reported in eight out of the twelve visited schools. The key informants revealed that there was general lack of interest coupled with fear of Mathematics out of a misconception that the subject matter was difficult. Some of the feedback on students' attitude towards Mathematics is reflected in the voices hereunder:

> *Most of these girls have developed phobia for mathematics. No matter what you do, they just believe that the subject is a hard nut to crack (**A teacher of Mathematics)***

> *The problem here is lack of interest in Mathematics. No one can pass Mathematics when there is no interest (**A teacher of Mathematics)**.*

These findings provide a pointer as to why most of the sampled schools registered dismal performance in Mathematics over the year. Appropriate pedagogical efforts should therefore be made to demystify Mathematics as a subject of study at secondary school level.

Regarding entry behaviour, the study revealed that most of the students join the sampled sub-county schools with low average marks. This is because by design, the sub-county schools are the lowest category of secondary schools in Kenya and are only allowed to select students after other schools in superior categories have done so. Consequently, the sub-county schools end up admitting weak students. This is then translated into dismal performance in Mathematics and other subjects. Some of the feedback is reflected in the voice hereunder:

> *Most of these students joined with very low grades. The scores in Mathematics ranged from 20% to 58% (**KII with teacher of Mathematics)***

5.2.2 School related challenges

Interview and observation data indicate that the major school related impediments to effective learning and teaching of Mathematics were large class sizes and inadequate teaching and learning resources. Class registers and observation data indicate that the classrooms were crowded with students beyond the recommended class size of 40 students in a single stream. This was supported by the teachers of Mathematics who noted that they were handling larger than usual classrooms. For instance, one teacher noted:

> *The policy on 100% transition from Primary level to secondary level has brought many challenges. There is hardly a space in the classrooms. We handle many students in a single stream, yet Mathematics requires regular supervised individual class practice and assignments. This is greatly compromised in the current situation. We are overwhelmed.*

Besides, crowded classrooms, qualitative evidence coupled with observations established that learning and teaching of mathematics was hampered by resource inadequacy. The observed sample schools did not have the required resources such as mathematics room, ICT resources, among others. In accordance with this observation, some participants hinted;

> *Ideally we should have a fully equipped Mathematics room. This way, the teachers can make adequate preparations while the students can undertake as much practice (**KII with teacher of Mathematics)***

5.2.3 Teacher related factors

Qualitative evidence coupled with onsite observations revealed that teacher factor was also responsible for the low students' achievements in Mathematics subject. In many instances, the teachers of Mathematics in the sampled schools confessed that they lacked capacity in innovative pedagogical approaches, especially the aspect of integrating ICT in teaching. An example of the feedback on extent of integration of ICT in teaching Mathematics is reflected in voice hereunder:

> *To be honest, we rarely use ICT in teaching Mathematics. Besides lack of infrastructure, the skills are limited on our part as teachers. (**KII with teacher of Mathematics)***

Furthermore, interview data indicate that there was low motivation among some teachers of Mathematics. This was attributed to unconducive working environment and limited support from the employer. For instance, one teacher noted:

> *The working condition in the sub-county schools is demoralising. The reward isn't commensurate to the work we do here. (**KII with teacher of Mathematics)***

5.3 Challenges with Respect to Chemistry Subject

The study revealed that students' academic achievement in Chemistry subject was hampered by a number of challenges. These challenges are presented systematically under the following three themes: Student related challenges; school related challenges; and teacher related challenges. Study findings on the listed themes are presented hereunder:

5.3.1 Student related challenges

Qualitative data indicate that the major student related challenges encountered in the sampled schools were low entry behaviour and general disinterest in Chemistry among the learners. Some of the feedback on students' attitude towards Chemistry is reflected in the voices hereunder:

> *When asked why they don't perform well in Chemistry, the students say that the subject matter is hard and boring (**KII with teacher of Chemistry)***

*Students say that Chemistry laboratory is so cold and unwelcoming. It's all about attitude (**KII with teacher of Chemistry)***

5.3.2 School related challenges

Interview and on site observation data reveal that the major school related impediment to effective learning and teaching of Chemistry was inadequate and ill equipped laboratories. Most of the observed sample schools had small Chemistry laboratories that were hugely dilapidated. In some instances, the laboratories only had stools and dry water taps. Fig. 9 and 9 show photos of laboratories in some of the visited schools.

This sorry state of affairs negatively affected the ability of the teachers to plan and conduct frequent Chemistry practical sessions. In accordance with this observation, some key informants hinted;

*Available laboratory is too small for all the students. This is because Chemistry is a compulsory subject. I have had to plan and conduct practical sessions on Sundays. This way, they come in small groups (**KII with teacher of Chemistry)***

*Teaching of Chemistry requires a lot of reagents. The problem is that the school cannot afford to buy adequate reagents for all the students (**KII with teacher of Chemistry)***

5.3.3 Teacher related challenges

Qualitative evidence reveals that student achievements in Chemistry subject was impeded by the challenge of inadequate trained teachers and lack of laboratory assistants. The data indicate that some schools only had one teacher of Chemistry and no laboratory assistant at all. For instance, in one of the interview sessions a teacher noted:

*I am the only trained teacher of Chemistry in this school. I have no laboratory assistant. Planning for instruction becomes a major headache (**KII with teacher of Chemistry)***

Fig. 8. Photo of an ill equipped laboratory in one of the visited schools

Fig. 9. Photo of a congested laboratory in one of the visited schools

Furthermore, interview data indicate that a number of teachers of Chemistry lacked capacity in innovative pedagogical approaches, especially the aspect of integrating ICT in teaching. The teachers however acknowledged that integration of ICT in teaching of Chemistry has the potential of bridging the gap.

5.4 Challenges in Biology Subject

The study revealed that students' academic achievement in Biology subject was hampered by a number of challenges. These challenges are presented systematically under the following three themes: Student related challenges; school related challenges; and teacher related challenges. Study findings on the listed themes are presented hereunder:

5.4.1 School-related challenges

Following the face-to-face interviews with the biology teachers, it emerged that several school-related factors influence academic performance in biology. Key among them were: Lack of teaching and learning materials. teaching and learning materials necessary for learning biology include biology laboratory, apparatus and equipment such as microscopes, charts and models. Relevant and recommended text books and revision materials are a requirement. Most schools had one laboratory serving all the three subjects. Kobura girls and St. Luke's Shisango girls did not have a laboratory. They had improvised rooms serving as laboratories. Furthermore, some schools had very limited space for expansion. Examples were ACK Ebusakami girls, Bukulunya secondary, St. Luke's Shisango girls, and Kobura girls. Large population due to the government policy on 100% transition from primary to secondary. The negative effect of this is large class sizes that hinder small group experiments and individualized attention. It also implies that the resources are stretched.

5.4.2 Teacher-related challenges

Poor academic performance in biology is influence by teacher-related factors such as Inadequate number of trained teachers, poor teaching methods that are theory-laden with very few practical sessions. In many schools, teachers seemed demotivated and with a negative attitude. They were teaching very many lessons and hence did not pay close attention to students. A good number of schools (8 out of 12), were understaffed. Furthermore, in ALL schools there were many Board of Management teachers who are on contract. Upon employment by Teachers' Service Commision, they are usually posted elsewhere. The turnover of such teachers is therefore very high. The implication is disruption of the smooth flow of the teaching and learning process, leading to inconsistencies.

5.4.3 Student-related challenges

Students' attitudes towards science subjects. The other factors identified by the subject teachers included mother tongue influence that makes interpretation and comprehension of biology concepts difficult, attitude, motivation, family-background, students not creative in application questions. Most students are admitted with low marks. This weak entry behaviour impacts negatively on their academic performance in biology. They are unable to interpret high-order questions

> Teacher 1: *"we receive very weak students with as low as 100 marks"*
>
> Teacher 2: *"Students come to school with an already formed opinion that Biology and other sciences are hard subjects and that they know they can't pass"*

More findings indicate that students are influence by mother tongue and hence find it difficult to understand and interpret questions. They are unable to answer application questions yet most biology questions are at the application level. It was also revealed that chronic absenteeism for a good number of students was impacting negatively on their academic performance. A good number of students come from poor background whereby parents are unable to clear school fees at the beginning of term. The students have to be sent home for school fees. Some of them over-stay at home.

In summary, the study findings showed that, students with positive attitude towards the Biology subject, register better performance in examinations and also the availability of teaching/learning resources in schools impacted positively on students' achievement in Biology examinations. It is recommends that: teachers should motivate students so as to build on positive attitude towards sciences, so as to able to compete globally in the careers. Schools without teaching/learning resources should strive to avail/procure them to improve results. There is

dire need of intervention in many of the schools visited.

5.5 Challenges in Physics

Meaningful learning of physics is the hallmark of a technologically competent workforce in science, technology and engineering. Despite the fact that very few students are opting for Physics as their science subject choice, most of the major courses at university require that a student should have done Physics in the Kenya Certificate of Secondary Examination (KCSE).

Diploma technical oriented courses also require that one should have done Physics to be admitted to the colleges. In this current baseline survey, interviews and document analysis were conducted. Several factors influencing academic performance in physics were identified and are presented thematically below.

5.5.1 School-related factors- resource challenges

Table 1 indicates resource challenges in all the schools, except Erusui Girls. Science subjects are practical dependent. Research shows a positive correlation between academic achievement and availability of resources. Teachers interviewed revealed that performance in sciences is poor due to inadequate laboratories and ICT infrastructure, electricity in many schools. Even the few laboratories available do not have adequate apparatus and equipment. Examples of such equipment include CRO and Xrays. Some teachers manage to integrate ICT in teaching but do not have an enabling environment to scale it up. Three teachers indicated that they have to improvise some of the apparatus as stated below:

> Teacher: *"You are forced to speak to jua kali people to make some apparatus for you"*

Timetabling in about 9 schools out of the 12 visited was cited as another factor contributing to poor performance in physics. This is due to the fact that Physics is elective at form three, hence blocked with subjects such as History and CRE. Students tend to opt for the humanity subject. The end result of this is low enrolment in physics.

5.5.2 Teacher-related challenges

The baseline survey revealed that teaching methods used and teaching resources also affect performance in Physics hence resulting into low enrolment as a ripple effect. Many teachers in many of the schools visited teach physics conventionally through lecture method, a heavily teacher-centred mode of content delivery. It was also revealed that some concepts and topics are very abstract, thus so demanding in terms of practicals and need research hence consuming a lot of time, yet some teachers do not have the capacity to conduct research. Furthermore, resources are limited to conduct the practicals, hence the dependence on lecture method of instruction. However, in three out of the selected 12 schools, physics performed better than the rest of the sciences. This was due to the teachers of physics integrating ICT in their teaching. However, they noted inadequate or lack of digital content. The teachers rely on networking with and borrowing the content from teachers in other schools. Below is a conversation with one of the teachers who integrate ICT in teaching physics.

> Teacher 1: *"I use my laptop to teach physics"*
>
> Interviewer: *"So where do you get digital content to teach physics?"*

Teacher 1: *"I borrow digital content and save on an external hard disk to teach my students, who really love the subject. It is the best performed subject, with a mean score of 5.6 in last year KCSE"*

However, the study further revealed many teachers are ICT compliant but do not integrate ICT in their teaching and the few who attempt have difficulty in selecting digital content. This is further complicated by lack of ICT infrastructure.

The Government directive of 100% transition from primary to secondary schools has resulted in large class sizes particularly in current form 1 and 2 classes against very few teachers. Teachers tend to be overloaded with many lessons and resort to teaching to the examination. Undertaking practical lessons becomes a problem due to these large classes. Many teachers interviewed expressed their frustrations as exemplified by their own voices:

Teacher $_{\text{biology}}$**:** *"It is very frustrating to teach a class of 60 plus. You are expected to set up experiments for the students. How do you do it with 60 plus students. To make matters worse, the apparatus are not enough. It is very frustrating"*

Teacher $_{\text{chemistry}}$: *"How can one teach practicals to a large class? You need to group them in grous of 4 or 5 but in my class I have groups of over ten. Some students give up and do nothing"*

In almost half of the schools visited, there was delayed syllabus coverage leading to limited time for revision and adequate preparation for examinations.

5.5.3 Student-related factors

The study revealed that students' attitude, gender , where girls fear physics (for example, at Bukhaywa secondary school, out of 30 students taking physics, only 3 are girls), weak entry behaviour in form one with as low as 100 marks in some schools, mother tongue influence, absenteeism, boy/girl relationship, lack of self-motivation and low self-esteem, negative peer influence, students weak in mathematics which impacts negatively on performance in Physics, lack of a proper reading culture, and teen pregnancy, are among the many other factors that influence learner's academic performance in Physics.

5.6 Challenges in Computer Studies

The study revealed that students' academic achievement in Computer Studies subject was hampered by a number of challenges. These challenges are presented systematically under the following three themes: Student related challenges; school related challenges; and teacher related challenges. Study findings on the listed themes are presented hereunder:

5.6.1 School-related challenges

Inadequate computers

The study established that there were inadequate computers in the schools. In one particular school, while computers studies is examinable, there were only 27 computers against 750 student population. This observation was supported by interview data. For instance, in one of the interview sessions, one teacher claims that:

> *All topics from Form II are practical that require students to work with computers. (KII with computer teacher)*

In support of this view, another Computer Studies teacher remarked that:

> *Accessing computers is a challenge to learners. In Form II all topics are practicals but we have 6 computers against 108 students (KII with computer studies teacher*

This problem had the net effect of discouraging learners thus affecting their attitude to the subject. A computer teacher lamented thus:

> *Most learners are meeting computers for the first time…when they experience problem of access they shy away. They end up learning computer studies like theory than practical that it should be… Form IV do projects…. they need one to one computer and they are 12 against 6 computers yet students need one to use for 7 months. We thus shorten the period each has with a computer to ensure the work is done. (KII with computer studies teacher).*

Lack of ICT Infrastructure

In a number of schools not offering computer studies, there was an attempt to have a room assigned as 'computer room' yet lacking adequate infrastructure and arrangement to make it so. Assigning a classroom as computer room could be a first step but the room should be fully equipped and designed to meet specifications of a computer room. A teacher lamented:

> *The labs need to be fully equipped (KII with computer teacher)*
> *Poor or lack of internet connectivity*

Interview data revealed that most schools lacked or did not have stable internet connectivity. This greatly hampered teaching of computer studies. For instance, one teacher observed that:

> *… . we rely on our own data bundles … which is quite expensive* (KII with a teacher)

5.6.2 Teacher related challenges

The study established that the schools that offered computer studies were faced with two major teacher related challenges: They are inadequate number of teachers of computer studies and lack of trained teachers of computer studies. For instance, in one of the schools, one there was only one untrained teacher hired on BOM terms handling students in both forms one and two with the student population of 238 and 200 respectively. Evidently, individual attention is compromised in such a situation.

6. CONCLUSIONS

The purpose of this baseline survey was to establish the status of learning and teaching of English and STEM subjects in twelve pilot secondary schools in Kakamega, Vihiga and Kisumu counties of Kenya.

The study established general trend of dismal performance of students in English and STEM subjects between the years 2015 and 2019. In specific, Mathematics, Chemistry and Biology recorded the least scores, especially among students in girl schools. The findings suggest gender differences in student achievements in STEM subjects. Moreover, lower scores were posted in English subject by students in day schools. However, the performance of students in Computer studies was generally remarkable. Only five out of twelve schools offered computer studies.

The baseline survey also established rising rate of student enrollments in the already resource constrained pilot secondary schools. This was attributed to the Ministry of Education's policy on 100% transition from Primary level to secondary level of education. The study established that the school infrastructure such as laboratories, libraries and classrooms were inadequate to effectively support learning. 25% of the schools lacked libraries while four schools improvised rooms to serve as libraries or book stores. The study also noted that there were inadequate resource materials to support learning in English and STEM subjects. Additionally, lack of internet access hampered effective use of ICT to support learning. Some schools relied on data bundles (sometimes bought by themselves) to support any ICT intervention that required use of internet facilities.

7. RECOMMENDATIONS

7.1 Recommendations for Action by Ministry of Education

1. Improve the quality and quantity of physical infrastructure in the secondary schools to match the growing student population which has been occasioned by the policy of 100% transition from primary to secondary education. In specific;
   a) Expand and equip laboratories to enable students undertake individualized and group practical exercises that are key to comprehending STEM subjects.
   b) Build libraries which will act as centers for individual and group learning. These will provide avenues for reading for pleasure as well as improve students comprehension and reading skills, all of which are necessary for effective comprehension, a skill needed not just in English language classrooms but in STEM classrooms as well.
   c) Build more classrooms to improve teacher-student ratios and to enable learner centered approaches to teaching of English and STEM subjects.
2. Improve the quality and quantity of human resource in secondary schools. In specific;
   a) Build capacity of teachers in methodology to improve their strategies of teaching English and STEM. Through reflections on various learning approaches and strategies, teachers can make learning more learner-centered and in sinc with learners experiences. Through this, learners will see the connections of learning and their daily experiences making learning STEM more meaningful to them.
   b) Employ more teachers to enable more learner centered approaches in teaching English and STEM subjects. Worst affected was Computer Studies where most teachers were untrained in pedagogy and employed by respective BOMs.
3. Investigate gender difference in enrollment and performance in STEM subjects at secondary school level and devise strategies of realizing parity.

7.2 Recommendations for Further Research

Suggested below are some of the areas that require further investigation.

1. Poor performance in STEM Education among secondary school students.
2. Gender disparity in enrolment and performance in STEM subjects among secondary school students.
3. Teen pregnancy, incest, early marriages, and school dropout among secondary school students.
4. Poor performance in English, the role of reading for pleasure, and the correlation between English and STEM Education.
5. Baseline survey on STEM Education on a national scale.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Bunshaft A, Boyington D, Curtis-Fisk J, Edwards T, Gerstein A, Jacobson C 2015. Focus on employability skills points to experiential learning. A publication by STEMconnector's STEM Innovation Task Force.
2. Crawley E, Malmqvist J, Östlund S, Brodeur D. Rethinking engineering education: the CDIO approach. New York: Springer; 2007.
3. Jang H. Identifying 21st century STEM competencies using workplace data. J Sci Educ Technol. 2016;25(2):284-301.
4. Ferrini-Mundy J 2013. STEM education: the administration's proposed reorganization. Presented to the Committee on Science. Space, and Technology, U.S. Washington, DC: House of Representatives.
5. Barakabitze AA, Kitindi EJ, Sanga C, Kibirige G, Makwinya N. Exploring students' skills and attitudes on effective use of ICTs: case study of selected Tanzanian public secondary schools. Univers J Educ Res. 2015;3(6):407-25.
6. Kanematsu H, Barry DM. STEM and ICT education in intelligent environments. Intell Syst Ref Libr. 2016.
7. Karigi MW. Factors Contributing to Poor Performance in Mathematics in KCSE in s selected Public Secondary Schools in Kiamba Division of Central, Province, Kenya. Strategic. J Bus Change Manag. 2015;2(2):315-32.
8. Owoeye D, Yala B. School facilities and academic achievement of secondary school agricultural science in Ekiti State, Nigeria. Asian Siciak Sci. 2010;7(7):34-56 Asian.
9. Onderi H, Makori A. Secondary school principals in Nyamira County in Kenya: issues and challenges. Educ Res Int. 2013;1(1):67-89.
10. Barrett A, Clegg J, Ali S, Hinostroza J, Lowe J, Nikel J et al. Initiatives to improve the quality of teaching and learning. A review of recent literature. United nations educational, scientific and cultural organization; 2007 [cited 15/12/2013]. Available:http://unesdoc.unesco.org/images/0015/001555/155504e.pdf.
11. Kinyua JW. A Study of Factors That Influence Performance in Mathematics in Secondary Schools by Female Students in Nairobi; 2001. Available:http://www.erepository.uonbi.c.ke
12. Mwaruma J. Integration of ICT in Teaching and Learning of Sciences in Perspective- A Case Study of a Secondary School. Retrieved from hppt:; 2015. Available: http://www.lr-library.ku.ac.ke.
13. Makori A, Onderi H. An evaluation of secondary school principals' perception of learning resources in free secondary education era; 2013.
14. Lockheed M, Vail S, Fuller B. How textbook affect achievement in developing countries: Evidence from Thailand. The World Bank. Education Evaluation and Policy Analysis. 1986;8(4):379-92.
15. Musasia A, Nakhunu S, Wekesa W. Investigation of factors that influence syllabus coverage in secondary school mathematics in Kenya. Int J Humanit Soc Sci. 2012;2(1):51-9.
16. World B. Textbooks and school library provision in secondary education in Sub[1]Saharan Africa, World Bank Working Paper no. 126: Africa human development series. Washington, DC: World Bank; 2008.
17. UNESCO institute for information technologies in education; 2004. Information and communications technologies in education. Position paper. Available from: http://www.iiep.unesco.org.
18. Semali LM, Mehta K. Science education in Tanzania: challenges and responses. Int J Educ Res. 2012;53:225-39.
19. Oakes J, Saunders M. Access to textbooks, instructional materials, equipment, and technology: inadequacy and inequality in California's public schools. Los Angeles: UCLA; 2002's Institute for Democracy, Education, and Access.
20. Ghavifekr S, Rosdy WAW. Teaching and learning with technology: effectiveness of ICT integration in schools. IJRES. 2015;1(2).
21. Chetty LR. The Role of Science and Technology in the Developing World in the 21st century. J Evol Technol. 2012;2(8):229-31.
22. Enrique Hinostroza J, Labbé C, Brun M, Matamala C. Teaching and learning

activities in Chilean classrooms: is ICT making a difference? Comput Educ. 2011; 57(1):1358-67.
23. Harris S. Innovative pedagogical practices using ICT in schools in England. J Comput Assist Learn. 2002;18(4):449-58.
24. Mbugua ZK, Kibet K, Muthaa GM, Nkonke GR. Factors contributing to students' poor performance in mathematics at Kenya Certificate of Secondary Education in Kenya: A case of Baringo County, Kenya. Am Int J Contemp Res. 2012;2:87-91.
25. Ojuok JO, Gogo JO, Olel MA. Influence of physical facilities on academic performance in constituency development fund (CDF) built secondary schools in Rachuonyo South sub-County, Kenya. Afr Educ Res J. 2020;8(3):462-71.
26. Nasambu MG. Influence of availability of equipment, learning Aids and facilities on practical abilities of learners in physics in Sirisia division, Bungoma west sub-county, Kenya; 2020.
27. Government of Kenya. Kenya vision. Vol. 2030. Nairobi: A Globally Competitive and Prosperous Kenya. National Economic & Social Council (NESC); 2008.
28. CEMASTEA. A report on the baseline study for Science, Technology, Engineering, and Mathematics Model Schools in Kenya. Nairobi: Unpublished; 2017.
29. Wanzala O. Mass failure in science subjects spell doom for Kenya's growth. Daily Nation.
Available: http://www.nation.co.ke; 2019.
30. Usman A. The relevant material resources to the teaching and learning of Arabic and Islamic studies. An Encycl Arts. 2007;7(1):47-52.
31. Adeogun AA, Osifila G. Relationship between educational resources and students academic performance in Lagos State Nigeria. Int J Educ Manag. 2008;5(6):34-56.
32. Lowe, D. Newcombe, P, & stumpers, B. Res Sci Educ. 2012. Evaluation of the use of remote laboratories for secondary school science education;43(3):1197-219. DOI: 10.1007/s11165-012-9304- 3.
33. Oloo M. Fresh Plans to make Science Subjects more Attractive. Standard. 2018.
34. Oduor A. School Labs Pathetic as Head teachers Hide Equipment. Standard; 2017.
35. Newhouse CP. STEM the boredom: engage students in the Australian curriculum using ICT with problem-based learning and assessment. J Sci Educ Technol. 2017;26(1):44-57.
doi: 10.1007/s10956-016-9650-4.
36. Ogunniyi MB. An Analysis of laboratory activities in selected Nigerian secondary schools. Eur J Sci Educ. 1983;5(2):195-201.
37. Wisconsin library association foundation; 2006. Value and Importance of Libraries [cited Oct 25 2008]. Available from: http://www.wisconsinlibraries.org/research/value.asp.
38. Altbach PG. Perspectives on publishing in Africa. Publ Res Q. 1993;9(1):44-62.
39. Squire JR. Textbook publishing in encyclopaedia of educational research, vol 4. 6th ed. Macmillan. 1991;1419.
40. Odulaja G, Ogunwemimo K. Teachers attitude towards biology practical with particular reference to school ce; 1989.
41. Fowowe SO: 1988. Finding academic libraries in Nigerian university libraries. Ilorin Journal of Education, Vol. 8, (12-6).
42. Greene JC, Caracelli VJ, Graham WF. Toward a conceptual framework for mixed-method evaluation designs. Educ Eval Policy Anal. 1989;11(3):255-74.
DOI: 10.3102/01623737011003255.
43. Kothari CR. Research methodology, methods and technology. New Age. 2nd ed. New Delhi: International Publisher Ltd; 2011.
44. Creswell JW. Qualitative inquiry and research design: choosing among five approaches. 3rd ed. Thousand Oaks, CA: SAGE Publications, Inc; 2013.

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