International Journal of Multidisciplinary Research & Innovation
Volume 3. Issue 1, 2025. University of Kabianga, Kenya. ijmri@kabianga.ac.ke

Effects Of Stem Education Programme On Chemistry Performance Among Students In Extra County Secondary Schools In North-Rift Region, Kenya

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ABSTRACT

The study examined the effects of Science, Technology, Engineering, Mathematics (STEM) education programme on Chemistry performance among secondary school students in North-Rift Region, Kenya. The study was anchored on Social Learning Theory. Causal comparative ex post facto research design guided the study. The target population was 3550 form four students and 175 teachers of Chemistry. Simple random sampling was used to select six Counties in North-Rift Region. Stratified random sampling was used to separate schools to STEM and Non-STEM schools and simple random sampling technique was then used to sample out students and teachers. The sample size consisted of 1092 respondents. Data were collected using questionnaire, a document analysis schedule and a Chemistry achievement test. Reliability of the evaluation instruments was examined using test-re-test method. Data were analyzed using descriptive statistics and hypotheses were tested using t-test for independent groups. The study findings revealed that chemistry performance among students was good and was associated to STEM education programme. Study findings established that students' performance in Chemistry in STEM schools (Mean 21.68, SD 6.17) was higher than in Non-STEM schools (Mean 19.06, SD 7.15). The difference in mean scores in STEM and in Non-STEM schools was established to be statistically significant implying that students' performance in Chemistry was dependent on the school where a student studied whether STEM or Non-STEM. The Chemistry performance in both categories of schools was greatly associated to STEM Education programme under implementation, which was more effective in STEM schools than in Non-STEM schools. The number of Chemistry projects presented by students was higher in STEM (173) than in Non-STEM schools (144). The study also established that students lacked adequate space to design projects and hence it was recommended that an innovation room (makerspace) be constructed in each school to enhance creativity and innovation and allow students to expand on the number of Chemistry projects.

Keywords: Science, Technology, Engineering, Mathematics, Performance

1.1 Background of the Study

Science, Technology, Engineering and Mathematics (STEM) Education programme was introduced in selected Extra County Secondary Schools in Kenya in the years 2016 and 2017. Implementation of STEM education programme was done in 102 extra county secondary schools whereby promotion of inviting school climate in terms of the 5ps (people, process, policies, programs and place) was emphasized; promotion of creativity and innovation among students and creation of Maker Space or innovation room in each of the selected STEM Model schools. The implementation process in Kenya is coordinated by Center for Mathematics, Science, and Technology Education in Africa (CEMASTEA). Selection of STEM schools and implementation of STEM education programme in Kenya was guided by several policies in education namely: The Kenya Constitution of 2010; Science, Technology and Innovation Policy and Strategy (2008); Basic Education Act of 2013 and Sessional Paper No. 2 of 2016 which promoted education reforms and training in Kenya. The Institute for Capacity Development of Teachers in Africa (ICADETA) Strategic Plan also referred to as the CEMASTEA Strategic Plan of 2014-2019 strived to strengthen teachers' skills in STEM.

CEMASTEA was supposed to initiate a programme that would promote STEM activities for example student competitions and exhibitions. CEMASTEA was also to sensitize students, teachers and all other school stakeholders on STEM functions towards achieving sustainable development (CEMASTEA, 2014). It is therefore through this plan that STEM education programme was initiated and rolled out in the selected schools. STEM education programme was developed to guide implementation of STEM activities in schools. Teachers of mathematics and sciences together with principals were trained on the expectations of STEM schools. According to STEM programme, Mathematics, Physics, Chemistry and Biology are supposed to be taught as one since they are interrelated; learner centred teaching methodologies are emphasized; creativity and innovation among learners should be championed; students' attitude towards mathematics and sciences will improve and effective utility of teaching/learning resources will also be realized. Students' discipline too will improve and learner enrollment will also rise. All these will in turn affect students' performance in mathematics and sciences. Ministry of Education through CEMASTEA promotes STEM implementation through STEM education programme in selected Kenyan secondary schools. This is the sixth year since STEM education programme was rolled out in schools in Kenya. Its effects have already been felt in the selected institutions and other schools which have benefitted from STEM schools.

During the World Economic Forum of (2017) held in Geneva, young people were encouraged to study science, technology, engineering, and mathematics subjects for a more employable workforce to be created in different Nations. The subjects could enable students to acquire employment than those who have

pursued other courses. Evaluation of STEM education was done by Stith (2017) in Missouri and established that STEM had impacted on the learning outcomes of students and provided a continuous improvement on curriculum implementation. STEM has also been adopted by various countries in Africa seeking to integrate STEM education into secondary education. For instance Nigeria have shifted and championed STEM literacy in secondary schools as observed by Salami (2012) who conducted

a study and the findings indicated that there has been low performance among learners in science subjects in West African learning institutions. Mwangi (2017) also established that developing countries in Africa are facing serious shortage in STEM related jobs worsened by lack of interest and motivation among students in STEM subjects at high school level. Manoah, Indoshi and Othuon (2011) conducted a study in Kenya to examine on students' attitude and performance in mathematics in public secondary schools and established that that students' performance was influenced by attitude whereby students with positive attitude performed significantly better in examinations than those with negative attitude.

1.2 Statement of the Problem

Performance of students in National examinations in STEM subjects (Mathematics, Physics, Chemistry and Biology) in most secondary schools in Kenya has been low, according to Kenya National Examinations Council (KNEC) yearly reports. The national mean scores for Chemistry since the inception of STEM programme in secondary schools were: 28.01 (2021), 30.19 (2020), 20.71 (2019), 24.05% (2018), 26.90% (2017) and 26.10% in 2016. North-Rift Region forms part of Rift-valley Region in Kenya and KCSE Chemistry mean-scores have also been low, over the years. From these results, it is evident that in most of the years, Chemistry registered mean scores of below 30%, implying that most learners have not pursued STEM related careers associated to Chemistry and thus North-Rift Region and the entire nation will not have enough engineers, medical doctors, nurses and other science related professionals despite the introduction of STEM education programme in schools.

Various researchers have conducted studies on STEM subjects and factors influencing their performance among students. Sanchez (2019) evaluated robotics, a product of STEM education programme and established that robotics influenced students' interest in STEM subjects leading to improved students' performance. Nelisa (2022) conducted an evaluation of STEM in Physics in Nairobi Metropolitan Region, Dzana (2012) established that lack of science equipment had contributed to the decline in students' academic performance in sciences. King'onia et al. (2017) established that schools' climate was not inviting and negatively affected students' academic performance.

The reviewed studies have focused on other subjects with minimal attention specifically made on Chemistry. Focus has also been made to teaching/learning resources and school climate on learners' performance. No study on STEM and STEM education has been done in the Counties in North Rift Region. The purpose of this study therefore was to examine the effects of STEM education programme on students' performance in Chemistry in Extra County Secondary Schools in North-Rift Region, Kenya.

1.3 Research questions

1. What is the extent of students' performance in Chemistry in extra county secondary schools in North-Rift Region, Kenya?
2. What is the extent of students' participation in STEM Chemistry projects in extra county secondary schools in North-Rift Region, Kenya?

2. LITERATURE REVIEW

2.1 Theoretical Framework

Social Learning Theory by Albert Bandura (1975) guided the study. This theory emphasizes that students interact, make observations during learning process and imitate the characters/behaviors of their colleagues. According to the Social learning theory both cognitive and environmental factors combine and influence student learning and modify their behavior from the observations in the learning environment. The theory recognizes that after learning something, it may or may not result in students' change in behavior or character. Bandura observed that students learn from one another and copy characters they have observed among themselves. Students will consequently develop positive behaviors and character learnt from one another consequently resulting to improved academic performance. STEM education programme championed collaboration and teamwork among students to learn from one another as also noted in the Social Learning Theory.

3. METHODOLOGY

Sileyew (2020) defined a research design as a framework that guides how research will be conducted. It is a blue print for data collection, analysis and interpretation to gain answers to evaluation questions. Quantitative research paradigm was adopted. The study employed causal comparative ex post facto research design. This design was used to since both the cause and the effect were examined after they had occurred without manipulating the independent variable. STEM education programme in the concluded study was the independent variable while Chemistry performance was the dependent variable. The inception of STEM education programme in schools was perceived to have had effects on the students' performance in Chemistry and hence information on implementation of this programme and its effect on students' performance in Chemistry were therefore established through the study.

3.1 Target Population

The target population was 6 Counties comprising of 25 Extra County secondary schools in North-Rift Region. Extra county schools were targeted since STEM education programme was implemented in these schools. Out of the 25 Extra County schools, nine were girls' school categories while 16 were boys' school categories. 12 schools were STEM model schools while 13 were non-STEM schools. The total number of form 4 students in STEM schools was 1620 and 1930 students were in Non-STEM schools. A total of 3,550 form 4 students were therefore targeted, whereby 2125 were boys and 1425 were girls. The reason why form 4 students were targeted was because they had interacted with STEM programme for the longest period as compared to other students in other forms and therefore were appropriate to participate in the study.

175 teachers of Chemistry were also targeted. Teachers of sciences and mathematics in STEM schools were trained on STEM education in mathematics and sciences and they were to implement the skills learnt in their schools. The teachers therefore possessed information regarding the extent of implementation of STEM programmes and hence they were targeted.

3.2 Sample and Sampling Procedures

Simple random sampling technique was used to select four out of six Counties in North-Rift Region. This sampling method was appropriate since it gave every County an equal chance of being selected to participate in the study. To ensure representativeness of schools in each of the selected Counties, stratified random sampling was used to categorize schools into two: STEM model and Non-STEM schools. Since two schools had been identified by Ministry of Education as STEM schools in every County, a total of 8 STEM schools were identified by purposive sampling to form one stratum, consisting of 4 boys' and 4 girls' schools. The other statum consisted of 11 Non-STEM schools and stratification was further done to categorize them into girls' and boys' school categories as this approach gave each school, based on gender, an equal chance of being selected. From each strata, simple random sampling was then used to select 4 boys' schools and 4 girls' schools totaling 8 Non-STEM schools to participate in the study. A sample size of 16 schools was therefore obtained

to participate in the study, comprising of 8 STEM and 8 non-

STEM schools.

Form four classes were selected by purposive sampling technique since they had interacted with STEM education programme for the longest period of time. Each of the Extra County schools had at-least two streams at form four. Simple random sampling was used to select one stream of form four class in each of the selected schools to participate in the study to arrive at a total of 16 streams. Simple random sampling technique gave each stream an equal chance of being selected and hence was a suitable method. Each stream had between 40 and 75 students. From the selected streams, the number of students sampled out from STEM schools were 521 out of 1620 and 519 students were sampled out from 1930 students in Non-STEM schools. A total of 1040 students were therefore sampled out from a population of 3550 to participate in the study. Mugenda and Mugenda (2013) observed that a representative sample of 10 % to 30 % of the population is suitable for a study. The sample of 1040 (29.3 %) students was therefore a good representation of the entire students' body in extra County secondary schools in North Rift Region.

Due to varied distribution of Chemistry teachers, three to six teachers in each of the sampled schools (STEM and Non-STEM) were selected at random to participate in the study. A total of 52 out of 175 teachers of Chemistry were selected, comprising of 30 teachers from STEM schools and 22 from Non-STEM schools as schools had varied teacher distributed with a larger population from STEM schools.

3.3 Research Instruments

A document analysis schedule was used to collect data on past performance of students in the Kenya Certificate of Secondary Education (KCSE) in Chemistry from the subject head. A questionnaire was used to collect data from teachers. A Chemistry achievement test was used to collect data on students' performance in Chemistry among the 2022 form 4 candidates in both STEM and STEM schools.

3.4 Validity of the Research Instruments

Research experts were requested to examine the validity of the research instruments' results. They examined face and content validity of the research instruments. The chemistry achievement test was pilot tested to a selected sample of respondents from two schools within Rift-valley region.

3.5 Reliability of the Instruments

Test-retest method was used to test for the reliability of the Chemistry achievement test. The evaluator used the two sets of results obtained from the test and computed Pearson product moment correlation co-efficient and found to be 0.72 while that of the questionnaire was 0.81. The items in the chemistry achievement test were therefore considered reliable since they yielded a correlation coefficient greater than 0.6 according to Mugenda, (2013).

4. FINDINGS

Students' Performance in Chemistry

A Chemistry achievement test was administered to form 4 students in the selected schools. The total mark which was to be scored by students was 30. Tables 1 shows the summary of the findings obtained.

Table 1

Mean scores for the Chemistry Achievement Test by Category of Schools

Category of school	Mean	n	Std. Deviation
STEM	21.68	521	6.17
Non-STEM	19.06	519	7.15
	20.37	1040	6.80

The findings presented in Table 1 show that the Chemistry mean for STEM schools (21.68) out of 30 was higher than that of Non-STEM schools (19.06). The findings on students' performance in Chemistry achievement test were good with students in STEM schools performing better than those in Non-STEM schools. Teachers observed that the high mean scores were associated to STEM programme under implementation in schools. The standard deviations were 6.17 and 7.15 for STEM and Non-STEM schools respectively. Based on the findings in Table 1, it is evident that the standard deviation for STEM schools (6.17) was lower than that of Non-STEM schools which was 7.15.

The standard deviations were large to imply that each of the students' scores in both categories of schools deviated greatly from the respective mean scores. The findings on mean scores in the two categories of schools may be attributed to positive students' attitude towards Chemistry in STEM schools which might have been influenced by teaching methods, motivation methods, and the variation of the adequacy of Chemistry resources as observed by Okoth et al. (2018) who established that inadequate instructional resources significantly affected students' performance in science subjects. Students' motivation level also contributes to varied students' performance as observed by Chan and Norlizah (2017) that students' motivation towards science learning had a significant relationship with students' achievement in science.

A hypothesis to examine the significant difference in mean scores based on the category of school was done using t-test for independent groups. Table 2 shows the findings obtained.

H01: There is no statistically significant difference between mean Chemistry performance scores of students who studied in STEM and Non-STEM schools.

Table 2

t-test for difference between School Category and Mean Chemistry Performance Scores

School Category	n	Mean	Std. Deviation	t-value	Sig. Value
STEM	521	21.68	6.17	6.32	0.00
Non-STEM	519	19.06	7.15		
n	1040	20.37	6.80		

The findings presented in Table 2 shows that a t-value of 6.32 and p-value of 0.00 were obtained. The p-value (0.00) was less than the acceptance level of 0.05 and this was an evidence to reject the null hypothesis. The null hypothesis that there is no statistically significant difference between mean Chemistry performance scores of students who studied in STEM and Non-STEM schools was therefore rejected. The finding implied that students' performance in Chemistry was dependent on the school where a student studied and this may be attributed to variations in the adequacy levels of Chemistry teaching/learning resources, among other factors, which influenced students' performance as observed by Gaotlhobogwe (2012) that inadequacy of learning resources affected students' attitude and perception towards design and technology resulting to varied performance. The difference existing in mean scores may be associated to varied distribution of resources in schools putting in consideration that CEMASTEA equipped STEM schools with additional resources for Chemistry, among other STEM subjects and hence the schools were likely to perform better than Non-STEM schools.

Teachers' views concerning students' performance in Chemistry in their schools were established. Table 3 shows the findings.

Table 3

Extent of Students' Performance in Chemistry According to Teachers

		Extent of performance of students in Chemistry in examinations			
		Poor	Good	Very Good	n
Category of School	STEM	1 (3.3%)	27 (90%)	2 (6.7%)	30 (100%)
	Non-STEM	6 (27.2%)	14 (63.6%)	2 (9.1%)	22 (100%)
	n	7 (13.5%)	41 (78.8%)	4 (7.7%)	52 (100%)

From the data displayed in Table 3, 1 (3.3%) of the teachers in a STEM school and 6 (27.2%) of the teachers in Non-STEM schools reported that the performance of students in Chemistry in their schools was poor; 27 (90%) and 14 (63.6%) of the teachers in STEM and Non-STEM schools respectively viewed that the performance was good while 2 teachers each in the two categories of schools translating to 6.7 % and 9.1 % of the teachers from STEM and Non-STEM schools respectively pointed out that the performance of their students in Chemistry was very good. From these findings, it was evident that performance of the students as observed by 27 (90 %) of the teachers in STEM schools was good as compared to that of Non-STEM schools where 14 (63.6%) of the teachers reported that the performance of students was also good. According to teachers, students' performance in Chemistry was associated to STEM education programme under implementation in schools. The variation in students' performance in Chemistry may be attributed to adequacy levels of learning resources as observed by Kimeu et al. (2015) who established that availability of classrooms, laboratory apparatus and chemicals influenced students' academic performance.

Extent of Students' participation in STEM Chemistry Projects

Creativity and innovation was a chapter presented in the STEM Education Programme. At secondary school levels, students design projects and participate in competitions at all levels from Sub-County up-to Nationals. Students' performance with regard to projects work in schools was examined. Data on students' performance in Chemistry projects in STEM and Non-STEM schools were collected from teachers and are as presented in Table 4.

Table 4

Number of Chemistry Projects Presented by Students in STEM and Non-STEM Schools

STEM Schools	Non-STEM Schools	n
173 (54.6%)	144 (45.4%)	317 (100%)

The findings displayed in Table 4 showed that the number of Chemistry projects presented by Chemistry students from STEM schools in 2022 were 173 representing 54.6% as compared to those of Non-STEM schools which was 144 corresponding to 45.4%. The findings indicated that the number of Chemistry projects from STEM schools was higher than those of Non-STEM schools. This may be due to the varied distribution of resources. Space in laboratories was noted to be a challenge limiting students' interactions with Chemistry projects. CEMASTEA equipped STEM schools with additional resources in Chemistry and this may be attributed to the higher number of Chemistry projects presented by students. The higher number of Chemistry projects presented by students from STEM schools than in Non-STEM schools could also be associated to the variation in students' attitude towards Chemistry which possibly arose from the variation of the distribution of teaching/learning resources in schools as observed by Gaotlhobogwe (2012) who established that inadequacy of learning resources affected students' attitude and perception towards design and technology.

4.1 Conclusion

Based on the findings of the study, it was concluded that students' performance in Chemistry was good. Students in STEM schools performed better than those in Non-STEM schools. Chemistry performance in schools was greatly associated to STEM Education programme under implementation. The study further concluded that students were involved in Chemistry projects, though at a higher level in STEM schools which is also an effect of STEM education programme. Space in the Chemistry laboratories is inadequate and hence students do not optimally design projects.

4.2 Recommendation

On the basis of the findings and conclusion of this study, an innovation room (makerspace) should be constructed in each school to enhance creativity and innovation and allow students expand the number of projects.

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