Effect of Scientific Competencies in Chemistry Practical on Performance in Chemistry Subject

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Abstract

Practical work plays a key role in the instruction of science and chemistry in particular. This study was done to evaluate the effect of learner competencies in Chemistry practical on performance in chemistry examination in secondary schools. The objective of the study was to evaluate the effect of observation, manipulation and computation competencies in chemistry practical on performance in chemistry subject. The study was carried out in Narok County of Kenya. The County was selected because performance in chemistry has been below average and inconsistent over the years as observed from KCSE Chemistry mean grades of 2012 to 2017. Research philosophy used was pragmatism. A descriptive survey design was used where a sample size of 377 respondents were randomly selected from chemistry teachers and Form three students from 145 public secondary schools in the County. Data was collected using questionnaire, interview and observation schedule. Document analysis was also used to obtain required information for the study. Data was analyzed using descriptive statistics with the aid of statistical package for social science (SPSS). Analysis of Variance (ANOVA) was used to test the hypotheses. The findings of the study indicated that observation, manipulation, problem solving and computation skills were low which translated in low performance in majority of the schools. Entry characteristics of students had a small impact on performance in chemistry practical. The ANOVA result indicated that science skills which included observation, manipulation, problem solving and computation had positive significant effect on the performance in chemistry ($P < .05\%$). The study concluded that student competence had significant effect on the performance in chemistry. It recommended that there is need to adopt new instructional methods like computer-based learning, cooperative learning and guided inquiry laboratory methods to enable students develop science competencies to improve their performance. The results will benefit Ministry of Education, Donors, County governments, teachers, students and researchers to realign measures for effective content delivery in Chemistry.

Keywords: Observation, Manipulation, Computation, Performance

INTRODUCTION

The development of a highly competitive and integrated economy, technological innovations, and a growing knowledge base continue to have a profound impact on people's lives (CDC, 2007). Like other science electives Chemistry, provides a platform for developing scientific literacy and for building essential scientific knowledge and skills for lifelong learning in science and technology in order to meet the challenges posed by these developments.

Through the learning of chemistry, it is possible to acquire relevant conceptual and procedural knowledge. Moreover, it helps to develop understanding and appreciation

of developments in engineering, medicine and other related scientific and technological fields. Additionally, according to CDC (2007), learning about the contributions, issues and problems related to innovations in chemistry will help learners develop an understanding of the relationship between science, technology, society and the environment.

Chemistry involves hands-on, or activity or student-centered, pretty than lecture method or "chalk and talk" method which encourages rote learning. A laboratory is a school building equipped with facilities, materials and apparatus which students' use, in carrying out investigations (Achimugu, 2012). According to Odum, (2013), Chemistry Practical exercises are usually done in a laboratory using pieces of apparatus and chemical reagents. Chemistry is basically a research facility action situated subject. No course in the subject can be considered as total without counting commonsense work in it. Research facility is utilized to depict the viable exercises where understudies embrace chemicals and hardware to make discoveries and solve scientific problems. The initial reasons for the advancement of research facility work in chemistry education lie within the need to create gifted professionals for industry and exceedingly competent specialists to inquire about research (Belay, 2012).

Tunde, (2010) reported that when students are rarely exposed to practical work it resulted to poor communication and observational skills. The absence of the skills gave rise to students' poor performance in chemistry especially in volumetric analysis. This was seen in the study where students were unable to make observations and communicate their findings in chemistry practical because they were exposed to laboratory activities occasionally.

The American Association for the Advancement of Science (AAAS) study incorporated fundamental and integrated process skills in an intervention. Results indicated that there were improved handling abilities in science lessons which raised the level of execution in science by boys. Abungu, (2014) discovered that education science with an emphasis on handle abilities for advancing execution in science showed a positive result. Lucenario, Yangco, Punzalan and Espinosa (2016) examined the adequacy of Academic Substance Knowledge-Guided Lesson study (PCKLS) as an intercession to create PCK competencies among instructors and subsequently improve understudy accomplishment in terms of conceptual understanding and problem-solving abilities. Examination of information appeared that there was a noteworthy contrast within the science educator competencies of the PCKLS of the gathered instructor respondents as compared to those of the customary gather. Too, understudy respondents appeared a critical addition on low scores in terms of conceptual understanding and problem-solving abilities.

Practical exams are major contributing factor to poor performance in sciences since students are not exposed to them as required (KNEC, 2009). Kenya National Examinations Council (KNEC) (2013) reported that, while the number of students taking chemistry in secondary schools has been high, their performance in practical examination is wanting. This is because practical examination determines the grade which a student is to be awarded. This report suggests that students were unable to skillfully manipulate the apparatus, make accurate observations and also fail to make accurate records to be used to make scientific conclusions. The report indicated that the weakness shown by the students was because serious exposure to practical work is lacking (KNEC, 2009).

Chemistry teaching should be approached by use of investigatory methods. Experiments ought to be performed and results be carefully analyzed to promote student understanding of concepts (KNEC, 2007). Practical approach of instruction is a requirement for all teachers and therefore students should be permitted to experiment and develop imaginative thinking skills required in the education system (KNEC, 2009). The general country's KCSE performance in chemistry are presented in table 1 below.

Table 1: KCSE Performance in Chemistry from the year 2009 to 2013

	No. of Students who sat for KCSE chemistry examinations	**Mean score**	**Proportion of students (%) (equivalent)**
2009	329,730	38.28	21.14
2010	347,364	49.84	27.98
2011	403,070	47.33	25.19
2012	427,386	55.88	31.17
2013	437,847	49.66	27.79

From the above observations, the percentage scores in Chemistry was low and has not been consistent over the years. The scores show that practical paper has been below fifty percent and this means that a lot has to be done in the laboratory to enhance practical activities. Practical approach of instruction should start when students are admitted to secondary school. They should be allowed to carry out experiments themselves to enable them make discoveries on their own environment and arouse more interest in the subject (KNEC, 2013).

In Narok County, KCSE performance in Chemistry has been very poor too as shown by the low mean grades over the years as presented in table 2 below.

Table 2: Chemistry KCSE Mean grades

Year	2012	2013	2014	2015	2016	2017
Mean Grade	2.783	2.766	2.775	3.887	2.534	2.316

From the mean grades, it can be concluded that the performance in Chemistry in the county is poor and inconsistent. In this science subject practical paper determines candidates' mean grade to be awarded and therefore when practical paper is not performed well then the overall grade of the student drops. Science process skills are the sequences of events that researchers are engaged in while taking part in scientific investigations and all those activities that contribute to scientific learning (Chebii, 2011). In the present study, the skills to be studied are manipulation, observation, reading, recording, computation and interpretation. They have been selected for this study since they are the skills required during K.C.S.E examination practical. This study was conducted to evaluate the effect of learner competencies used by the learners' when performing chemistry practical.

METHODOLOGY

Research philosophy was pragmatism where both quantitative and qualitative data were used to define relationships among variables Sauders, (Lewis and Thornhill, (2012). The design selected was descriptive research design. The choice was suitable to provide characteristics of a population. A sample group was used to provide information relating to the problem of study then findings obtained were generalized, Best and Khan (1993).

The research study was carried out in Narok County of Kenya. The County was selected because performance in chemistry has been below average and inconsistent over the years and it lagged in the provision of quality education to its young people due to inadequate infrastructure for instruction NAYS, (2015)

At the time of study, there were 145 secondary schools in the County. The target population comprised 365 chemistry teachers and 6,314 Form three students making a total target population to be 6679 respondents. Form three students were selected because it was a class in which many topics were practically oriented. The target population was stratified into two strata.

Table 3: Target Population and Sample Size

Respondents	Target population
Chemistry teachers	365
Chemistry Students	6,314
Total	6679

Source: County Education Office, (2019)

The sample size was determined by using Yamane's Taro formula, $n = N / 1 + N (e)^2$. Where n= Sample size, N=Population, e= acceptable sampling error of plus or minus 5% (0.05). Hence the results were given by;

$$n = \frac{N}{1 + N(e)^2}$$

Where;
n = the sample size,
N = the population size,
e= the acceptance sampling error
$= 6679/1+6679(.05)^2$
$=6679/1+16.6975$
$=6679/17.6975$
= 377 respondents

Stratified sampling was used where stratified sample formula (Sample size of the strata = size of entire sample / population size * layer size) to calculate the proportion of respondents Neville & Sidney (2013)

$n_h = (N_h / N) * n$

Where n_h is the sample size for stratum h, N_h is the population size for stratum h, N is total population size, and n is total sample size as given in the sample frame below (Table 4).

Table 4: Sample Frame

Respondents	Target population	Sample distribution
Chemistry Subject Head	365	21
Students	6,314	356
Total	6679	377

Source: Research Data (2019)

Multi-stage sampling techniques were deployed. First the -schools were divided into Sub-County using cluster sampling technique. Simple random sampling was used to select the schools to be used for study. Purposive sampling was used to select one chemistry teacher and proportion of Form three chemistry students. The sample was obtained through lottery.

Questionnaire, Interview and observation schedules were used as the main research tools in the study. Data were analyzed using statistical package for social science (SPSS). Analysis of variance (ANOVA) was used to test the hypotheses. The data were then displayed (presented) using tables.

RESULTS

Demographic Results

Demographic results on student's questionnaire outcomes were summarized as given by the gender of the students as well as proportion of chemistry students. The results of gender of the students are presented in Table 5.

Table 5: Gender of Students

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	115	35.3	35.3	35.3
Female	211	64.7	64.7	100.0
Total	326	100.0	100.0	

Source: Research Data (2019)

Table 4 revealed that based on gender of the students out of 326 who were given questionnaire materials 115 were male representing 35.3% while 211 were female representing 64.7%. This study revealed there were more female than male in the schools within the region. Female students were given equal opportunities in school as male unlike in the past where most female students dropped out of school. 100% took chemistry in Form three.

Scientific Competencies and Chemistry Performance

Investigation on scientific competencies was conducted using a questionnaire, interview and observation schedule. The results from the questionnaires were presented using frequencies, percentages and mean using strongly disagree = 1, disagree = 2, neutral = 3, agree = 4 and strongly agree = 5. The results for scientific competencies and chemistry performance were presented in the Table 6 below.

Table 6: Scientific Competencies and Chemistry Performance

Questions	5(SA)	4(A)	3(N)	2 (D)	1 (SD)	Mean
The students use observation skills in chemistry practical lesson.	9(2.8%)	126(38.7%)	147(45.1%)	33(10.6%)	11(3.4%)	3.27
The students use manipulative skills in chemistry practical lesson	11(3.4%)	106(32.5%)	128(39.3%)	48(14.7%)	33(10.1%)	3.04
Chemistry knowledge is applied by students to solve practical's related problems.	15(4.6%)	111(34.0%)	154(47.2%)	31(9.5%)	15(4.6%)	3.25
Entry marks has affected learners' understanding of chemistry practical procedures.	6(1.8%)	76(23.3%)	78(23.9%)	75(23.0%)	91(27.9%)	2.48
Students' use	16(4.9%)	126(38.7%)	131(40.2%)	31(9.5%)	16(4.9%)	3.25

computation skills in Chemistry practical.						
Students copy the work done by others and give out affecting competence in practical	6(1.8%)	71(21.8%)	53(16.3%)	57(17.5%)	139(42.6%)	2.23
Students ability and competence in chemistry practical affect chemistry subject score	42(12.9%)	105(32.2%)	82(25.2%)	49(15.0%)	48(14.7%)	3.14

Source: Research Data (2019)

Table 6 gives a summary of questions that evaluated if the students used observation skills in chemistry practical. There were 9(2.8%) strongly agreed, 126(38.7%) agreed, 147(45.1%) neutral, 33(10.6%) disagreed and 11(3.4%) strongly disagreed. The results revealed that somehow the students were able to use observation skills in chemistry practicals. It implied that observation skills assisted to a smaller extent in performance in chemistry practical (mean of 3.27). There is need to improve the development of the skills of the students based on the low level since it is significant in the performance of chemistry practical and the subject in general.

It was examined if students used manipulative skills in chemistry practical lessons. The results showed 11(3.4%) strongly agreed, 106(32.5%) agreed, 128(39.3%) neutral, 48(14.7%) disagreed and 33(10.1%) strongly disagreed. It was revealed that 35.9% were in agreement as opposed to 24.8% who disagreed. This meant that manipulation skills were practiced to a smaller extend in chemistry practical (mean of 3.04). Manipulation skills being one of the competencies that assist students to handle chemistry practical activities needs to be well developed for it is crucial in obtaining data for problem solving.

The results from assessment if chemistry knowledge was applied by students to solve practical related problems are given. The responses indicated that to a small extent 15(4.6%) strongly agreed, 111(34.0%) agreed, 154(47.2%) neutral, 31(9.5%) disagreed and 15(4.6%) strongly disagreed. A mean of 3.25 confirmed that knowledge from chemistry was applied to a small extent in solving practical problems. There is need for students to develop understanding of chemistry subject content to enable them apply in practical activities for better performance.

Practicals were assessed using the question if entry marks affected the understanding of chemistry practical procedures. It was found that 6(1.8%) strongly agreed, 76(23.3%) agreed, 78(23.8%) neutral, 75(23.0%) disagreed and 91(27.9%) strongly disagreed. The results showed that 25.1% agreed as opposed to 50.9% who disagreed. It implied that entry mark affected to a small extent performance in chemistry practicals (mean 2.48). Students can improve their performance despite the entry behaviour.

Students' computation skills were evaluated on utilization in chemistry practicals. It was found that 16(4.9%) strongly agreed, 126(38.7%) agreed, 131(40.2%) neutral, 31(9.5%) disagreed and 16(4.9%) strongly disagreed. Computation skills were utilized to a small extent in chemistry practicals (mean of 3.25). It is important to develop the skill since it helps the students handle practical problems that affect their performance.

Students copy the work done by others and give it out was analyzed on its effect to competence in practicals. Those who strongly agreed were 6(1.8%), 71(21.8%) agreed, 53(16.3%) neutral, 57(17.5%) disagreed and 139(42.6%) strongly agreed. Those who generally agreed represented 23.6% and 60.1% disagreed. It implied that most students believe that coping or cheating in chemistry practicals does not affect their performance (mean of 2.23). Despite that, it has been a bad vice though most students support the fact. It is then very crucial to uphold morality and reduce mal practices in secondary school education.

Students ability and competence in chemistry practical were investigated where 42(12.9%) strongly agreed, 105(32.2%) agreed, 82(25.2%) neutral, 49(15.0%) disagreed and 48(14.7%) strongly disagreed. The results revealed that students' ability and competence in chemistry practicals had influence on the scores in chemistry subject to smaller extent (mean of 3.14). Therefore, it revealed that schools have to improve students' competence and skills in chemistry practicals to enable them perform well in the subject.

Interview Results

Interview results showed that majority of students had low observation, manipulation, and computation skills. The teachers had been trying to improve the skills as well as competence of the students. However, some teachers claimed that some students with low entry marks had poor observation skills which were anchored on the foundation of science at primary level. This was evidenced by teacher 12 who claimed that "the students had poor observation skills since most of them came from low performing primary schools with poor foundation in science affecting their performance in chemistry". This did not deter performing schools where chemistry teacher 10 claimed that the school had adequate and conducive environment that made students develop observation skills which assisted in improving performance in chemistry practicals and the subject at large. This was seconded by chemistry teacher 3 who said "we have enjoyed good performance in Chemistry since the school has given us resources and a conducive environment where students develop and utilize observation skills. This has contributed to better performance in chemistry practicals and the subject in general in our school". On the contrary schools with inadequate laboratory apparatus and reagents had problems when it comes to making observations during chemistry practical sessions.

In response to whether the students were able to manipulate apparatus during practical session. There were 12 teachers against 9 who agreed that their students were not capable of using manipulation skills. It indicated that there were insufficient manipulation skills among students and required utilization of innovative instructional methods to equip them with necessary abilities for better performance.

The response to whether the students were able to compute practical data to solve problems or not. Majority of the teachers responded that most of the students had challenges in computation of data. According to chemistry teacher 1, "Yes, most of the students are unable to link the data obtained to the taught concepts of moles, chemical equations and qualitative analysis". Chemistry teacher 3 responded that, "No, the students are introduced to practicals mainly in Form Four due to late coverage of syllabus leading to inadequate development of computation skill required in summative evaluation. Those who responded that majority of students had low abilities in computation were 11 out of 21 chemistry teachers representing 52.4%. They cited the main challenge as low scientific skills based on their background and lack of sufficient practical exposure.

Majority of chemistry teachers claimed that entry behaviour played a significant role in performance of students. Chemistry teacher 21 claimed that "Yes, students who had poor background in science when joining secondary school had poor foundation of major skills necessary in the development competencies in science based subjects. There were 14 chemistry teachers representing 66.7% who claimed that entry behaviour did have significant impact on students' performance. On the contrary those who disagreed claimed that with right resources and environment, students with poor background in science had equal chance of improving in science related subjects. Chemistry teacher 3 commented "no, with well-equipped laboratory and conducive environment students with poor entry behaviour can do well in chemistry practicals and the subject in general".

Observation Results

The results from observation were based on the assessment of what was observed in the actual practical. The observations were entered into observation schedule where mean and standard deviation were obtained.

Table 7: Observation on Science Competence

	N	Mean	Std Dev
Students have strong ability to make observations	21	2.5238	.67964
Students follow instructions in chemistry practical	21	2.4762	.51177
Students are knowledgeable in practical sessions	21	2.9048	.76842

Source: Research Data (2019)

Table 6 revealed that students somewhat had low observation skills (mean of 2.5238) where the total mean was five. Variance was low in observation skills (standard deviation of .67964). Majority of students were not able to follow instructions in chemistry practicals (mean of 2.4762). There was low dispersion in following instructions (standard deviation of .51177). Finally, students were knowledgeable to small extent in practical sessions (mean of 2.9048). Variance was low in knowledge ability of students (standard deviation of .76842). Low variance means that most of the respondents gave similar views. The observed information concurs with student's information which indicated low observation, manipulation, and knowledge application and computation skills among students. Therefore, it was evident that students' utilization of science skills and competence was low in the schools examined and this has contributed to poor performance in chemistry practical paper and the entire subject.

ANOVA results

To examine whether there existed any significant differences on scientific competence on chemistry performance, ANOVA was conducted. The following results were achieved using 5% significant level.

Table 8: ANOVA on effects of scientific competencies on chemistry performance

			Sum of Squares	df	Mean Square	F	Sig.
Perform in chemistry practical * Ability and competence	Between Groups	(Combined)	33.261	4	8.315	13.271	.000
	Within Groups		201.123	321	.627		
	Total		234.383	325			

Source: Research Data (2019)

The ANOVA results in table 8 indicated that scientific competencies affected the performance in chemistry significantly ($F_{(P=5\%,\ 4,321)}$ =13.271, P = 0.000 <0.05). F- ratio between group variance to within group is 13.271; since the value is closer to the mean hence variance is low. P< 0.05% - used to explain the significance level. Since the value is below 5% it means there is a significant relationship between variables and therefore the null hypothesis is rejected the alternative hypothesis is accepted. It implied that scientific competencies played a major role on performance in chemistry. Chemistry abilities and competence had significant influence on performance in chemistry practical.

DISCUSSIONS

Scientific competencies include observation, manipulation and computation skills. The study finding indicated that majority of students had low observation skill in chemistry practicals mean of 3.27. The utilization of manipulative skill in chemistry practicals was low mean of 3.04. A mean of 3.25 confirmed that knowledge from chemistry content was utilized to a small extent in solving chemistry practical problems. The students' computation skill was found to be low with a mean of 3.25. The three major skills are crucial in chemistry practical activities yet were not well developed and utilized by students in the study. The results concur with the findings from observation schedule that student's ability to follow instructions and utilize learned knowledge in chemistry was below average affecting performance in chemistry practicals.

Entry behaviour affected the performance in chemistry practicals to some extent mean of 2.48 which did no concur with teacher's view where entry behaviour of students had significant impact on performance. On the contrary, with adequate resources and conducive learning environment students with low entry behaviour performed well in chemistry practicals and the subject in general. Students who copied the work done by others affected their competence in practicals to small extent mean of 2.23. However, students' abilities and competence impacted the performance in chemistry practical to a small extent mean of 3.14 and this has affected the students' scores.

ANOVA results indicated that student's competencies had significant effect on performance in chemistry (P < 5%), meaning that there was a significant relationship between variables. The competencies are observation, manipulation, computation and problem-solving skills that had significantly affected the performance in chemistry. The students indicated low levels of the skills which have contributed to low performance in chemistry practical examination and the subject in general in the region.

These results concur with Lucenario, Yangco, Punzalan and Espinosa (2016) which found that science competencies of students and teachers significantly affected performance in science-based subjects' chemistry, biology, environmental science, mathematics and physics. The current research associated performance with low application of observation, manipulation, computation and problem-solving skills in chemistry practicals. This was supported by Lucenario et al, (2016) especially problem-solving skills which increased the mean score of students' despite intervention of Pedagogical Content Knowledge-Guided Lesson.

In another related study by Vincent-Ruz and Schum (2017) science competencies affected positively the performance of girl's which concurs with the current study. Teacher's competence was found to have positive significant effect on student's academic performance, despite the study concentrating on teacher's competence rather

than students' competence. Similarly, Copriady, (2014) found that teacher competences play a significant role in student's academic performance. Arokoyu and Needom (2019) found that teacher's competence in volumetric analysis depended on their qualification and was translated to students' performance. However, that was not clarified whether the teachers' competence or any other factor was associated with low science competence and skills level of students in chemistry practicals. Therefore, teacher competence in chemistry practicals proposedly associated with science competencies of the students' which affect performance in chemistry.

According to Adlim et al, (2013) low performance in rural schools was associated with students who had low competencies which concurred with the findings of this study. These are some of the factors that affect the current research, since the results indicated that science competencies were at low level in this study which explain the reasons for poor performance in the subject in summative evaluation.

CONCLUSION

Science competencies used by students like observation, manipulation, problem solving and computation skills were low which had negative impact on performance in chemistry. Entry mark affected performance in Chemistry to a small extent. Most of the students were unable to follow instructions during practicals which affected their outcomes. The current study found that scientific competencies significantly affected performance in chemistry

RECOMMENDATIONS

Chemistry teachers should enable students develop science competencies through laboratory interactions to enhance performance in examination.

Students should be guided to apply learned concepts in chemistry theory to solve practical problems.
School management should improve on teacher supervision especially during laboratory sessions and provide professional advice for proper instruction.

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