

## **Relevance of Kenya secondary school chemistry instruction in preparation of students pursuing chemistry at university level**

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### **Abstract**

*Chemistry is one of the most important branches of science and its knowledge is necessary in the understanding of composition, properties and behavior changes of matter that form the environment around us. Chemistry is highly important in modern societies because of its requirement as a prerequisite to the study of many other science oriented courses such as medicine, engineering and pharmacy. Due to the significance of chemistry, there is need for students to be academically prepared at secondary school level for higher level pursuits. Chemistry as a subject in Kenya is introduced to learners at secondary school level. The purpose of the study was to explore the relevance of secondary school chemistry instruction in preparation of students pursuing chemistry at university level. The study sought to determine whether secondary school background, learning environmental experiences and pedagogical experiences are in accordant to preparation of students pursuing chemistry at the higher level. The study employed descriptive research design and data was obtained using questionnaire. The subjects of study were second year students taking chemistry courses as a main subject. The research was carried out in selected universities in Kenya. Descriptive statistics such as frequencies and percentages were used for data analysis. Results indicated that students find secondary school chemistry relevant in the courses they are pursuing but proper coverage of syllabus, more practicals and more projects would make it more relevant and appropriate. The findings of the study may provide insight to chemistry educators to refocus student preparation in secondary schools and equip them with knowledge and skills necessary to help them solve problems in everyday life rather than passing exams and fitting in prestigious careers.*

**Keywords:** Relevance, Chemistry Instruction, Preparation of Students, pedagogical experiences, environmental experiences.

### **1.0 Introduction**

Chemistry as a science is fundamental to understanding the world and it aims at providing knowledge of a variety of chemical applications and their importance in everyday life. Chemistry has been recognized as a very significant science subject and its importance in scientific and technological development of any nation has been widely reported (Adesoji & Olatunbosun, 2008). Chemistry is an enabling discipline that underpins the sciences, environment, medicine, forensics, space sciences and industry (Royal Society, 2015). Chemistry plays an important role in most aspects of modern science and technology, from biotechnology to the creation of new materials and medicines (Yavon, Evans & Karabinos, 2003). High school Chemistry has been identified essential to further coursework in all sciences since it is a core subject and prerequisite in the study of many

other courses. Chemistry offers so many different career opportunities and can be a powerful springboard to launch into a whole spectrum of careers, scientific and nonscientific. Due to the significance of Chemistry, there is need for learners to be academically prepared at initial stage to equip them with prior knowledge which is the pre-condition for accumulating further knowledge and basis for learning process (Schneider, Korkel & Weinhert, 1990).

Chemistry is inherently practical subject where scientific concepts, principles and skills are developed through experimental investigation. Also learning of scientific knowledge requires discovery method and more experiential approach through hands-on laboratory procedures. It requires getting the students involved and most of the topics involve a lot of demonstrations and practicals but this becomes a challenge when classes are large or when schools lack essential facilities such as laboratories, apparatus and chemicals. Students tend to understand and recall what they see more than what they hear as a result of using laboratory in the teaching of sciences but most schools lack functional laboratory (Farounbi, 1998).

In teaching of Chemistry, it should be ensured that pupils develop the ability to analyse and evaluate the role of Chemistry in society. Learners should develop ability to handle chemical laboratory equipments, plan and carry out experiments, make observations, describe, interpret and explain chemical processes using natural scientific models. Students need to actively construct their own personal awareness and meaning in Chemistry (Usman, 2000). Chemistry practicals are aimed at giving the learners the opportunity to gain meaningful learning, acquire appropriate skills and attitude that enable them contribute to the development of society. Chemistry teaching is supposed to be result oriented and students-centred and can be achieved using appropriate methods and resources in teaching the students (Adesoji & Olatunbosun, 2008).

Despite the importance of Chemistry and the efforts made by researchers to enhance performance, students' performance in the subject in national examinations has been poor. The candidature in Chemistry has been on increase over the years. Table 1 show the candidature and national performance in Chemistry in Kenya from 2010 to 2013.

Table 1:

The KCSE Chemistry Candidature and Overall Performance from 2010 to 2013.

<b>Year</b>	<b>Candidature</b>	<b>Mean</b>	<b>Standard Deviation</b>
2010	347364	49.79	31.57
2011	403070	47.31	33.51
2012	427386	55.86	34.10
2013	439847	49.00	32.10

Source: KNEC 2014

The overall performance in Chemistry was a mean score of about 50 over the four-year period from 2010 to 2013. The overall performance dropped from a mean score of 55.86 in 2012 to 49.00 in 2013. The candidature continued to increase due to introduction of subsidized secondary education in 2008. The candidature went up from 347364 in 2010 to 403070 in 2011, an increment of 16%, while from 403070 in 2011 to 427386 in 2012, an increment of 6% and 427386 in 2012 to 439847 in 2013, an increment of about 3%. The large numbers of students pose a challenge to physical, material, financial and human resources available for Chemistry instruction.

By studying chemistry, the students develop a deeper understanding of chemical properties, improve analytical and evaluative skills as well as ability to communicate effectively and problem solving. To promote scientific literacy, an outstanding high school chemistry curriculum will expose and engage students in activities that involve problem solving and critical thinking (ACS, 2012). Although school chemistry programs are set out to

develop conceptual understanding and in-depth learning of content by students, the relevance of the teaching in providing a useful education is suspect (Pak, 1997). It is therefore necessary to investigate the relevance of secondary school chemistry instruction and explore whether it appropriately enables students to learn and accumulate further knowledge in universities.

### **1.1 Statement of the Problem**

In Kenya, two science subjects are compulsory to all learners at secondary level. Learners perceive chemistry as a subject that demands less effort for much success, simpler science and so they opt to take it. Hence the enrolment in chemistry is very large and has continued to grow over the years leading to large lecture-based classes. Students join universities with diverse set of pre-existing factors associated with student chemistry background, their high school learning environment experiences and pedagogical experiences that strongly influence their success in the courses. Hence there was need to investigate the relevance of Kenyan secondary school instruction in preparation of students pursuing chemistry at university level.

### **1.2 Objective**

The objective of the study was to investigate the relevance of secondary school chemistry instruction in preparation of students pursuing chemistry at university level.

## **2.0 Research Methodology**

The study adopted descriptive research design as it is concerned with conditions, practices, structures, differences or relationships that exist, opinions held, processes that are going on or trends that are evident. This design involves the collection of data that will provide account or description of individuals, groups or situations and attempts to describe, explain, document aspects of a situation as it naturally occurs and interpret conditions of present (Polit & Hungler, 1999). The design was then appropriate for this study. The actual sample size was 100 second year students that were purposefully sampled. The participants were second year students in different programs with chemistry as a major course from selected universities in Kenya. The students had attended various secondary schools from different parts of Kenya before joining university representing the diversity in the country.

Relevant data for this study was generated through questionnaire administration. The questionnaire had three sections. Section A sought the demographic information of participants; section B consisted of items seeking insights about the environmental experiences students had in secondary schools; section C had items that sought the pedagogical experiences of the learner on appropriateness of secondary school instructions. All the information from the questionnaire was summarized and analyzed. The analysis and interpretation focused on the objective of the study. The results were tabulated and summarized in graphs and tables.

## **3.0 Results and Discussion**

This section presents the research findings in line with objective that guided the study. The analysis is done systematically in accordance with the questionnaire presented to the respondents.

### **3.1 Response Rate**

According to Mugenda and Mugenda (1999) a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent. The questionnaire was administered to

100 respondents. Out of 100 questionnaires that were distributed 94 were returned representing a return rate of 94%. None of questionnaire was discarded due to improper fillings. The response rate of 94% was excellent for analysis and reporting.

### 3.2 Socio-Demographic Information of the Respondents

Information obtained on socio-demographic characteristics focused on their sex, age, grade obtained at KCSE, program of study, career course and type of secondary school attended. The data is given on Table 2.

Table 2: Respondents Socio-demographic Information

Characteristics		Frequency	Percentage
Sex	Female	38	40
	Male	57	60
Age in years	19	24	27
	20	33	37
	21	17	19
	22	13	14
	23	03	03
Program	BED	29	34
	BSc	56	66
Grade attained at KCSE	C+	2	2
	B-	0	0
	B	15	16
	B+	20	21
	A-	21	23
	A	36	38
Type of school attended	Day school	25	27
	Boarding	69	73

Data in Table 2 shows that the students who participated in the study were 60% males and 40% females. It implies that there was imbalance in chemistry courses in favour of males. The results displayed on Table 2 indicates that 38% of the participants attained maximum qualification (grade A) which implies that they had obtained a grade that facilitated academic and professional advancement in careers that require chemistry. The data also show that the respondents' age ranged from 19 years to 23 years. Majority of the respondents (73%) attended boarding schools while 27% were in day schools. A total of 66% of the respondents are in Bachelor of Science program while 34% of students are in Bachelor of Education (Science) taking chemistry as one of the teaching subjects.

Regarding the science subjects that the learners took after form two, 54% of students enrolled in three science subjects (chemistry, physics and biology) while 46% enrolled in two science subjects and out of this, 37% took biology/chemistry and 9% took physics/chemistry. The three sciences are related or interconnected and are of academic importance or contribution since an understanding of chemistry requires little knowledge of biology and physics. The respondents choose (two sciences) which are less challenging subjects due to the pressure many students feel to produce good grades. A total of 37% of respondents never took physics yet fundamental laws that govern the behaviour of matter apply both in chemistry and physics. It is also important to study

physics and chemistry to know the states of matter and also know about the atmosphere and its significance in life of humans, animals and plants.

About 41% of the respondents scored lower grades than they expected. The students identified various reasons that made them not achieve the expected grades such as inadequate staff, incomplete syllabus, inexperienced staff, and some said they handled the practical wrongly, inadequate facilities and insufficient resources.

The respondents pointed out that they wanted to pursue professional careers in fields such as engineering, nursing, pharmacy, medicine, computer science, biochemistry, laboratory science, actuarial science and teaching. Out of the respondents who participated, 76% of students indicated that they are not pursuing the career they intended while 24% of respondents are pursuing the career they intended to pursue after secondary school. This alludes that respondents had premature career decisions, did not get admitted to courses they preferred or did not perform well in KCSE.

In Kenya, high school grades are used for student placement into various university programs in that every course has its requirements based on cluster subjects. The students responded that they had limited knowledge and information about courses and more than half of them indicated that they did not get the minimum entry requirement for the course they intended to pursue. This shows that the respondents had not performed very well in chemistry so they were denied opportunity to explore intended career paths. A total of 78% of students indicated that they are not satisfied with the course they are pursuing. The respondents pointed out that there are various reasons why they are not satisfied with the career they are in such as not being passionate with the career since it was not their choice, not sure of the prospective job opportunities and not in the preferred career.

### **3.3 Environmental Experiences at Secondary School**

The recommended class size in Kenya is 45 students per class. A total of 59% of students indicated that their chemistry classes had large population of above 50 students. This shows that the teacher-student ratio was higher than expected. This implies that there were limited interactions between teachers and students' thus assessing students' understanding of concepts was difficult. Conducting practical may also have been challenging with these large student's populations. Also efficient management of a large group of students in fixed time schedule may have been hard. The findings are in line with Onocha (1985) who reported that large class size is un conducive for serious academic work.

At least 95% of respondents indicated their schools had one or more laboratories while 4% indicated they had no laboratories in their schools yet laboratory is an essential facility. Laboratory experiences should be used for problem solving and development of concepts. This alludes that some learners were denied the opportunity to manipulate materials to develop understanding of key concepts practically. The findings are in line with ACS (2012) that revealed that laboratory is an integral part of high school chemistry experience for it allows students to explore chemical concepts, view changes in matter and acquire scientific skills in atmosphere similar to a professional scientific environment.

Around 13% of students indicated that the schools that they were in, had temporary laboratories while 87% pointed out that their schools had permanent laboratories. This indicates that some schools lacked standard laboratories hence no conducive place for students to concentrate during practical lessons. This is consistent with Farounbi (1998) who asserted that students tend to understand and recall what they see more than what they hear as a result of using laboratories in teaching of sciences, yet some schools lacked functional laboratories. Also the finding coincides with ACS (2012) that remarked that high school laboratory should have the equipment necessary to conduct meaningful demonstrations and experiments since chemistry is a laboratory science and cannot effectively be learned without laboratory.

About 38% of students indicated that the apparatus and chemicals in their school laboratories were inadequate, 57% of respondents reported the school laboratories had adequate while 5% of students indicated that apparatus

and chemicals were not available in their schools. This implies that some respondents lacked sufficient apparatus and chemicals to perform experiments and so they had no effective laboratory experiences since they had little or no experience in reducing theory to practice. A total of 40% of students said that in form three and four they conducted one or two practical per month implying that students had limited use of hands-on experiences to learn concepts since laboratory work is a partner in the development of concepts and understanding. Thus students resulted having no effective laboratory experiences due to fewer experiments conducted yet laboratory experiences offers opportunities for genuine problem solving. The findings are in line with Adesoji and Arowosegbe (2009) who pointed out that teaching of practical activities tends to reinforce what is learnt during the theoretical class and it is expected to encourage among students, the spirit of experimentation, keen observation and such personality qualities as self-confidence, critical attitudes and perseverance.

A total of 87% of respondents indicated that in the schools they attended there was a chemistry technician/laboratory assistant while 13% of students said there was none. The chemistry technician/laboratory assistant provide assistance during practical classes like running of trials of experiment, preparing equipment and chemicals before lessons, working with individual students and supporting the students on projects. Thus the chemistry technician/ laboratory assistant ensure laboratory management by helping chemistry teachers with the preparation for practical activities and the teachers are able to use their time in lesson preparation and assessment of students.

Regarding the frequency of doing practical as a test, the results of students' responses are shown on Figure 1.

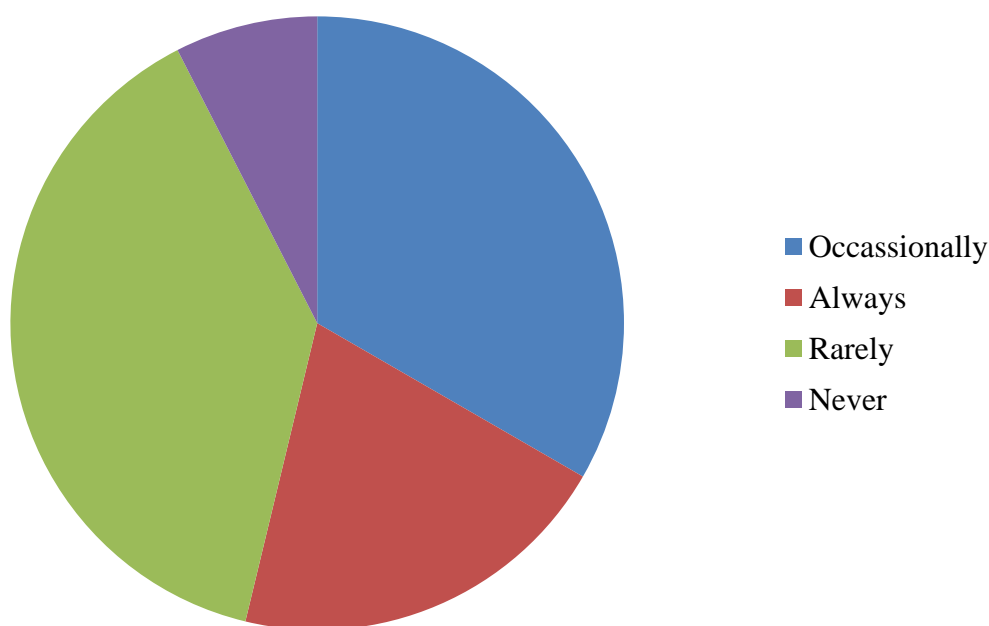


Figure 1: Students Responses on Frequency of Doing Practical as a Test

A total of 47% of students rarely or never took the practical as test implying they had limited practical skills preparation and were not able to make chemistry real and accessible. About 20% of the respondents did practical as a test always. The students should be allowed to manipulate materials to understand key concepts and perform better. The findings concur with Tai, Sadler and Loehr (2005) who asserted that laboratory work holds greater promise in helping to prepare students for college-level studies.

When students were asked how many chemistry academic trips they attended, 63% of respondents said they never attended any while 37% revealed that they went at least once for excursion. From the above responses, it is evident that majority of students were never taken for excursion hence no easy imagination of concepts learnt in the classroom. A total of 91% of students said they had no freedom in carrying out their laboratories activities

while 9% indicated that they were not restricted in conducting practical. This suggests that learners could not develop ability skills to handle chemicals and laboratory equipment on their own. The skills could be worthwhile in the students' lives.

### **3.4 Pedagogical Experiences**

About 84% of learners indicated that secondary school chemistry topics are related to university chemistry topics while 16% were not on agreement with the statement. It is evident that secondary schools have enriched curriculum that goes beyond basic skills. A total of 90% said that topics covered in secondary schools help them understand chemistry at university. This implies that during transition into university some students had command over knowledge of subject matter.

A total of 96% of the respondents indicated that secondary school chemistry topics are useful to what the students are learning at university while 4% disagreed. The respondents noted various topics such as organic chemistry, structure and bonding, metals, states of matter, mole concept, electrochemistry, structure of atoms and periodic table, acids and bases, radioactivity and energy changes and rates of reactions that are secondary school chemistry topics and are useful to what the students are learning at university. When respondents were asked whether secondary school chemistry practicals are useful in carrying out practicals at university, 88% agreed while 12% disagreed. This shows the cumulative nature of chemistry content in that chemistry is a highly sequential subject and requires students to master material and build on the concepts learnt.

Only 2% of respondents said that in form three and four they were taught by peer teachers while 81% indicated they were taught by university graduates. This shows that some students experienced shortage of skilled teachers in chemistry. The findings collaborate with Aluko (2008) who pointed out one of the prominent factors contributing to persistence of students' poor performance in chemistry as lack of professionally qualified teachers.

About 38% of respondents pointed out that their teachers in secondary schools used a variety of teaching methods, 35% of respondents said that their teachers used discussion while 12% indicated that their teachers used lecture method. This eludes that active learning methods were used to the majority of respondents hence attention and interest in chemistry as a subject was raised resulting to better performance. The findings agree with Oloyede (2010) who observed that use of limited range of teaching strategies resulting in the chalk and talk method leads to poor performance in chemistry.

The respondents were asked whether their secondary school chemistry teachers used visual aids and models when teaching. The responses are shown on figure 2.

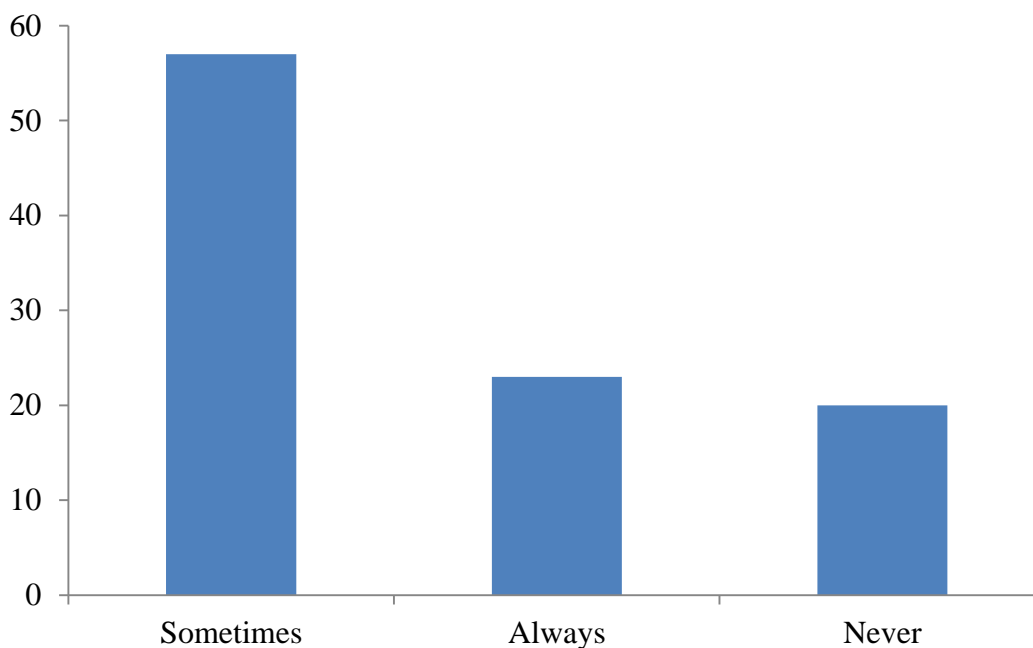


Figure 2: Students Response to whether their Secondary School Chemistry Teachers used Visual Aids and Models when Teaching

The results on Figure 2 show that a large proportion, 57% of respondents indicated that their secondary school chemistry teachers used visual aids and models sometimes while 20% of participants said their chemistry teachers never used teaching/learning resources. Use of visual aids and models enhance teaching and learning process by promoting active learning. The findings are consistent with Fiona and Andile (2009) who found out that many first year students in South Africa present an inadequate knowledge of the fundamental principles which underpin the study of chemistry and the problem emanates from the fact that many high schools have inadequate resources.

The respondents were asked other experiments that they conducted in form three and four apart from quantitative analysis. A total of 90% of the respondents pointed out that they carried out qualitative analysis while 10% indicated they conducted none other. This shows that the students did not deal with other content areas of practical work in secondary school chemistry but concentrated with some examinable areas where few apparatuses were required and where less preparation would be needed. Also the students lacked adequate exposure to practical work. This implies that students did experiments to prepare for national examinations yet experiments should be performed to generate data that will help answer scientific questions and understand abstract concepts. The findings are consistent with Orado (2009) who found out that the skills emphasized both in teaching and assessment of practical work in chemistry were the same skills as those assessed by KNEC.

Regarding the syllabus coverage, 15% of respondents said that they skipped some topics, 19% pointed out that they did not cover the syllabus well while 66% of respondents indicated that they covered all topics. This shows that a total of 34% of respondents had poor previous preparation for examinations since they had not covered the syllabus thoroughly. This implies that some respondents were poorly prepared academically for university. When students were asked how they obtained the chemistry notes, 9% of respondents said they made their own notes as the teacher taught, 12% of students copied the notes from the textbooks while 79% of respondents were given notes by the teacher.

The students were asked the number of times they carried out projects of their own design for chemistry in a year. The responses are shown on Table 3.



Table 3: Number of Times in a Year the Respondents Carried out Projects of their Own Design for Chemistry

Times	Frequency	Percentage
Once	14	16
Twice	10	11
Three or more	08	09
Never	57	64

The results on Table 3 show that 64% of the respondents never carried out project of their own design in chemistry while 16% of the students carried out once. This indicates that learners could not enhance creativity, critical thinking and acquire ability to make logical decisions. Students in secondary school should be encouraged to think creatively, critically and initiate their own projects based on scientific principles learnt in order to extend the scope of their subject. The projects make learners aware of the effect of scientific knowledge in everyday life thus they are able to appreciate their responsibility to the society. This agrees with ACS (2012) that argued that many students can best demonstrate achievement of course goals when they have the option to choose how to express their understanding through oral presentation, portfolios or creative projects.

Regarding the relevance of secondary school chemistry in relation to the course the students are pursuing, they noted that secondary school chemistry offered a foundation for university chemistry, offered important background knowledge and expanded knowledge to improve reasoning. Others described the secondary school chemistry as university preparatory program and elementary in content. This shows that the respondents found the secondary school chemistry relevant, applicable and meaningful.

## 4.0 Conclusion

The findings showed that students taking chemistry as one of the main subject at university find secondary school chemistry relevant. The students believe it forms a reasonable foundation, offer relevant background and is meaningful. However, some of the issues that arose from the research that requires to be improved so that the pedagogical and environmental experiences can make the students fit more in university are like have recommended class size, fully trained chemistry teachers, competent laboratory technicians and teachers use varied teaching methods. The findings also show that students would be ready better for university chemistry if they take the three sciences, be provided with enough laboratory, chemicals and equipment for carrying out more practicals and be facilitated to carry out sufficient projects.

## 5.0 Recommendations

From the findings of this research the following could be recommended:

1. The government and other stakeholders should construct sufficient laboratories, provide adequate teaching/learning resources and laboratory facilities to the schools for the purpose of improved teaching/learning in chemistry.
2. Chemistry teachers should redesign instructions and provide students with enriching activities designed to ignite the interest, motivation and imaginations of the learners to promote active learning.

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