Inquiry Learning in Secondary School Chemistry: Are Science Teachers Using IT?

*Peter Waswa[1] and Rose Cheptinget[2]
University of Eldoret, P.O. Box 1125 Eldoret, Kenya.[1,2]
*****Corresponding Author E-mail: pewaswa@gmail.com

Abstract

With the rapid developments in science and technology, Chemistry, which is fundamental to many disciplines, has become increasingly important. The number of compounds and their many different applications begs the question on how best to teach all the knowledge to students. To meet with the needs of society, reform in Chemistry teaching has taken place all over the world. However, it is difficult to teach students everything in this rapidly developing world. Accordingly, most science educators agree that students should be taught how to learn and apply Chemistry. It is also true that if people want to keep up with the development of knowledge, they should keep reflecting on how that knowledge has impacted on their lives. However, because the reformat has concentrated on knowledge structures, our teaching methods are still teacher-centred, not student-centred and do not encourage students to achieve lifelong learning and assessment. The purpose of the study was to assess teachers' use of science inquiry as a method of teaching Chemistry in secondary schools in Kenya. This paper discusses the extent to which Chemistry teachers use inquiring method as stipulated in the chemistry syllabus and the factors that hinder extensive use of inquiry method in the teaching of chemistry. A descriptive survey design was employed. The target population comprised 16 Form Three Chemistry teachers and 320 Form Three students in 16 selected secondary schools in Nandi North District. The 46 schools in the District were stratified into boys" and girls" schools and simple random sampling approach was used to select 8 boys" and 8 girls" schools. In each school, 20 students were selected using simple random sampling technique. The instruments used to collect data were questionnaire and interview, personal observations and documentary analysis. Data was analyzed using descriptive statistics. The study established that both teachers and students were in agreement that the Chemistry teachers did not use inquiry method to the extent stipulated in the syllabus. The findings of the study identified major factors hindering implementation of Chemistry inquiry method as lack of time due to congested syllabus, lack of resources and equipment, inadequate qualified Chemistry teachers and poor preparation.

Key Words: Secondary Schools, Chemistry Teachers, Inquiry Learning, Nandi, Kenya

Introduction

Inquiry learning involves the acquisition of skills, knowledge and positive attitudes through the learners‘ own initiative. The learner formulates a problem or is given one, plans the procedures, assembles equipment and materials then carries out investigations. Results are obtained analysed and conclusions made. In the process, learning takes place. In secondary school system in Kenya, this type of inquiry learning is done as students‘ projects. This is a learner centred technique of teaching which with effective guidance of the teacher, trains students to be inquiring scientists and is a major departure from conventional methods of teaching. Inquiring learning can offer effective learning opportunities if they are well organized. Farrant (1989) says that the main objective in science teaching is to help students develop the ability to carry out the whole process of scientific inquiry. Scientific inquiry also requires that the teacher knows the psychological level of the students in order to make teaching through inquiry fruitful.

Vaidya (1989) proposes that any inquiry learning successfully carried out must pass through the following stages:

The teacher and pupils propose various topics to be learned through inquiry or they may get the topic from the syllabus. He further states that the inquiry topic selected should be worthwhile, significant and rich in learning experiences and provide quality experience of a high order. In Kenya, the Ministry of Education through the KIE syllabus has already laid down the topics that can be done for inquiry learning.

The next stage is planning whereby students have to decide on the amount of work involved, materials and equipment needed, methods of collecting facts and the size of the group. This is an important stage, as proposed by Farrant (1980), gaining interest in what is to be learned is important as this is the starting point. He puts it metaphorically that you can lead a horse to the river but you cannot force it to drink. It is the same with students. Motivation is all important for getting students to learn. Once their attention has been captured, then the battle is half won.

The members of the group should be given as much responsibility as possible. Teachers should not underestimate children's capacity and need for an early development of quantitative experimental approach and presentation of such results. In addition, Swift (1987) advocates against the traditional way of introducing application of science at the end as a means of showing practical importance of concepts already

learnt. This approach has weakness as it emphasizes the importance of science itself, rather than application. He says the lack of time and stamina available for considering these applications may make inquiry learning not to be successful, instead Swift (1987) further suggests that without severe time and other constrains, the problem could form the basis of a long-term inquiry possibly involving visits and out-of schoolwork, perhaps through the science clubs.

Arthur *et al*. (2004) summarize the steps in a form of a cycle shown below.

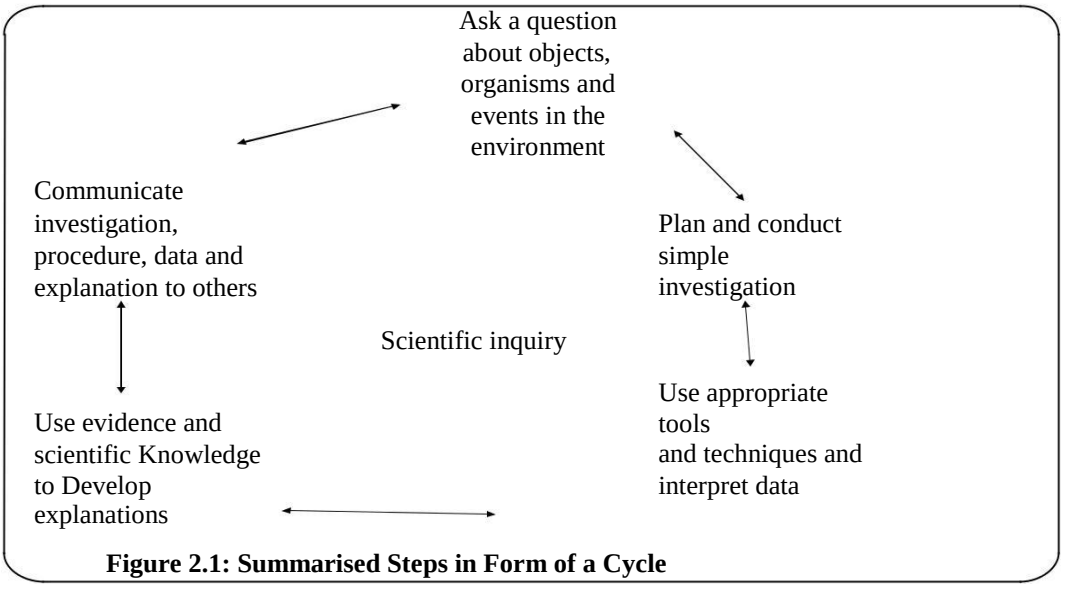

Figure 2.1: Summarised Steps in Form of a Cycle

The relevance and importance of Chemistry amongst the science subjects is formidable, hence the need for proper teaching of the subject in school so that students' scores in internal and external examinations would improve. According to Onwu (1981), teachers of Chemistry are expected to make it more relevant, enjoyable, easy and meaningful to students. Teaching methods need to be improved, and appropriate teaching strategies employed as the teaching-learning situation may demand. Agbola (2007) states that teachers should be concerned with the use of a variety of methods and procedures as learning can occur if a variety of teaching methods are used. Today experiential or "hands-on" learning is fast replacing or supplementing the traditional "chalk-talks". Experiential learning increases retention, motivates students to learn and encourages group co-operation.

Extent to which Chemistry Teachers use Inquiry Method of Learning as Stipulated

Because Chemistry involves a lot of experimentation, teachers have to make sure that they give learners an adequate number of practical projects to enhance understanding. For instance, Bradley *et al*. (2002) have described the importance of cooperative learning in Chemistry in which the lecture component diminishes in the first semester and essentially vanishes in the second. This is attributed to the fact that the information delivered in lectures is equally accessible from textbooks and notes; therefore, learners can read in advance and come to the laboratory to participate in the practical demonstration of what they have read.

Although inquiry learning and experiments are required and recommended in science classrooms, the teaching of Chemistry in Kenyan schools is reportedly too teacher-centred and there are insufficient learning aids for students to develop (Ministry of Education, 2000). Consequently, students invariably become passive receivers of information, which does nothing to enhance their conceptual understanding. Many students are not able to comprehend what their Chemistry teachers teach because Chemistry content is taught with the intention of finishing the syllabus and preparing for examinations. Little regard is given to how well the students understand Chemistry concepts. Therefore, a Chemistry teacher may be satisfied that he or she has covered the syllabus, only to be embarrassed by the poor examination results. While students may do well in written Chemistry examinations, the practical examinations, which are conducted separately, may prove more challenging to them.

Therefore, there is a need to familiarize students with the practical aspects of Chemistry, and this can only be done by giving them science inquiry projects to perform during the school term. In this way, it is hoped that the shortcomings witnessed in the performance of chemistry during examinations can be addressed.

It is important for Chemistry teachers to pay more attention to the value of inquiry activities, as not all students may benefit from an expository learning style, in which the teacher does all the talking and students are only expected to listen. In this regard, there is need to emphasize the importance of learning styles. Learning styles are defined as "personal qualities that influence a student's ability to acquire information, to interact with peers and the teacher, and otherwise participate in learning experiences" (Grasha, 1996). Blackmore (1996) concurs with this view, suggesting that one of the

first things educators can do to aid the learning process is to simply be aware that there are diverse learning styles in the student population.

A Chemistry teacher can capitalize on these different learning styles by organizing students into groups and assigning practical tasks to them. This will help students to learn in a more conducive environment than the lecture model of teaching, and will encourage participation. However, this form of instruction is not practiced widely, largely due to resource constraints, including lack of time (a demanding syllabus) and money (for lab equipment and chemicals). The importance of the laboratory in the teaching of Chemistry cannot be gainsaid.

The training of the teachers is also an important factor in discussing whether or not teachers make adequate use of inquiry learning in their instruction modules. According to Onwuka (1985) and Ughamadu (2005), no matter how well-developed and comprehensive a curriculum is, its success is dependent on the quality of the teachers implementing it. It follows that if a Chemistry teacher was trained predominantly through the lecture method, he or she will use it to teach students in secondary schools. This is borne out by the findings of Oludofun and Oguniyi (1981), Ivonwi (1997) and Ajaja (2005) which have shown that science teachers continue to teach science using the lecture method despite the recommended guided discovery/inquiry methods, which involve considerable use of projects to teach Physics, Biology and Chemistry. As stated earlier, the inability of science teachers to apply inquiry methods in their teaching is hinged on problems which include lack of laboratories equipped with facilities; large class sizes of Chemistry students with very few teachers and competency problems arising from the training of science teachers.

It is important that teachers develop methods of student-centred teaching and teacher ownership if teaching is to be meaningful for students (Mamlok, 1998; Rannikmae, 2001). The authors suggest that teachers should be able to develop teaching materials which reflect the relevant teaching approaches being advocated. However, as stated earlier, teaching aids in Chemistry are still only an approximation of the accuracy which can be achieved through using scientific inquiries to teach. Therefore, the use of learners‘ inquiry methods should be encouraged, rather than suppressed.

In conclusion, the arguments against the use of students scientific inquiries in teaching Chemistry are no longer valid, especially after the introduction of the 8-4-4-

education system in 1985, when the study of Chemistry became compulsory. The Chemistry syllabus encourages small group teaching through experiments and students‘ term inquiries (projects). Ideally, curriculum developers wanted Chemistry to be taught through these learner-based approaches; its teaching in secondary schools has remained largely expository (KIE, 1992; Kiboss, 1997; Mullei, 1987).

Statement of the Problem

In this study, the problem was to investigate the extent to which chemistry teachers use inquiry learning. The current dichotomy in Chemistry teaching is between those who are in favour of instruction through lectures and others who insist that inquiry learning is more effective. Currently, few teachers use inquiry learning as a method of teaching. Vaidya (2000) asserts that teaching through students‘ own inquiry is the most advocated method of teaching but is the least used method in science teaching in secondary schools yet it is one of the most stimulating and child-centred methods of teaching. Another proponent of inquiry teaching is Chenge (1996) who notes that pupils want to learn by discovery. They want to be actively involved in the learning process by investigating facts, sifting evidence and discussing concepts. This leads us to ask the question: Why don't Chemistry teachers ever use students‘ inquiry as a method of teaching? Indeed, the Chemistry KIE syllabus, textbooks and teachers' guides have topics for inquiry that should be undertaken by students. Another question one may ask is: are teachers aware of the contribution of students‘ scientific inquiries in enhancing learning? It is in search of answers to these questions that the author conducted a study at Nandi North District.

Although the proponents of each form of teaching may have conflicting opinions, it is necessary to state from the onset that neither the lecture method of teaching nor the inquiry method is intended to be mutually exclusive. Therefore, each form of teaching has to be used with the other.

Materials and Methods

The study sought to investigate the extent to which learner inquiry method of teaching was being used to teach Chemistry in secondary schools in Nandi North

District. The area is made up of two constituencies, namely Mosop and Emgwen and divided into six divisions. The study adopted a descriptive survey research design.

The study targeted all public secondary schools in Nandi North District. Head teachers, teachers and students served as the main respondents of the study. The schools were stratified as boys', girls', mixed schools. Seven schools from girls' schools' stratum were randomly selected and 7 from boys' and 2 from mixed schools respectively. The participants in the study comprised Form Three students randomly selected from the various schools already identified. From the above sampling procedures, the respondents who took part in the study were 16 Form Three Chemistry teachers and 320 Form Three Chemistry students.

The author used the following instruments to collect the data: questionnaires for Form Three Chemistry student and Chemistry teachers, interview schedules for head teachers, Chemistry achievement tests for Form Three Chemistry students, observation and survey of documented records methods. The data collected was analyzed using frequencies, means, standard deviation and percentages in interpreting the respondent's perception of the issues raised in the questionnaire so as to answer the research questions. In addition, the Pearson Correlation test was used to test the research questions.

Results

The Extent of Use of Inquiry method as stipulated in the Chemistry Syllabus

Analysis of whether or not teachers used topics or inquiry learning as stipulated in the syllabus was done from two perspectives. The first perspective analyzed teacher indications of their use of topics as stipulated in the syllabus while the second perspective examined the students' indications of whether teachers handled the inquiry topics as stipulated in the syllabus.

Teacher Indications of Inquiry Topics Handled. Analysis of teacher indications of whether or not they handled the inquiry topics as stipulated in the Chemistry syllabus is displayed in Table 1. Regarding investigating plant extracts and using them as acid/base indicators, 14(87.5%) teachers agreed to handling the topic and 1(6.3%) disagreed. Regarding determination of the amount of oxygen in water, 12(75%) agreed that the

topic was done, 3(18.8%) were not sure whether or not they had done the topic while 1(6.3%) disagreed.

Regarding identification of common pollutants of water from local sources, 15(93.8%) agreed that the topic was done while 1(6.3%) was not sure whether the topic was done or not.

Regarding atomic model construction, 12(75%) teachers agreed that the inquiry topic had been done, 3(18.8%) were not sure whether or not the topic had been done while 1(6.3%) disagreed. Regarding investigation of materials in terms of their structure and bonding, all the 16(100%) teachers agreed that the topic had been done. Finally, regarding construction and use of fire extinguishers, again all the 16(100%) teachers agreed that the topic had been done.

Table 1: Teacher indications of whether stipulated topics for inquiry had been done

	Indicators											
	Investigating plant extracts using them as acid/base indicators		Determination of the amount of oxygen in water		Identification of common Pollutants of water from local Sources		Atomic model construction		Investigation of materials in terms of their structure and bonding		Construction and use of fire extinguishers	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Disagree	1	6.3	1	6.3	0	.0	1	6.3	0	.0	0	.0
Not sure	1	6.3	3	18.8	1	6.3	3	18.8	0	.0	0	.0
Agree	14	87.5	12	75.0	15	93.8	12	75.0	16	100.0	16	100.0
Total	16	100.0	16	100.0	16	100.0	16	100.0	16	100.0	16	100.0

Students' Indications of whether stipulated topics for inquiry had been done

There was no evidence from both teachers and students if they did any other topic through inquiry learning. With forty-seven topics listed to be learned through student inquiry, only six confirmed to have been done represents a mere 12% of the expected learning by inquiry having been done. An earlier similar study conducted in Kakamega North District involving 206 students, 91 out of 206 (44.17%) of the students said they did only one chemistry project which was dealing with soap preparation. Four out of two hundred and six (1.94%) of the students reported that they did two projects

while 48 out of 206 (23.30%) of students said that they did not do any project in the secondary school chemistry course. Agreeing with the students‘ view, 16 out of 24 (66.67) teachers said their students did only one project, which was on soap preparation during the entire chemistry course. In a similar report, 13 out of 20 (65%) heads of department in questionnaire item no. 26 of HQS, said their students did not do any projects with 35% of heads of department in questionnaire item no. 27 of the HQS, saying the only project their students did was on soap preparation.

Students' Indications of whether Stipulated Topics for Inquiry had been done

Analysis of students' responses as to whether or not the syllabus stipulated topics for inquiry had been done revealed the information displayed in Table 2. As shown in the table, out of the 320 students sampled, only 316 returned their questionnaires. Regarding investigating plant extracts and using them as acid/base indicators, 246(77.7%) students indicated agreement to the topic having been done, 35(11.1%) were not sure while the other 35(11.1%) indicated disagreement.

Regarding determination of the amount of oxygen in water, 235(74.4%) indicated agreement that the topic had been done, 43(13.6%) were not sure while 38(12.0%) indicated disagreement. Regarding identification of common pollutants of water from local sources, 255(80.7%) indicated agreement, 29(9.2%) were not sure while 32(10.1%) indicated disagreement. Regarding investigation of materials in terms of their structure and bonding, 266(84.2%) indicated agreement.

Table 2: Student indications of whether the stipulated topics for inquiry had been done

	Indicators											
	Investigating plant extracts using them as acid/base indicators		Determination of the amount of oxygen in water		Identification of common Pollutants of water from local Sources		Atomic model construction		Investigation of materials in terms of their structure and bonding		Construction and use of fire extinguishers	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Disagree	35	11.1	38	12.0	32	10.1	23	7.3	22	7.0	22	7.0
Not sure	35	11.1	43	13.6	29	9.2	31	9.8	28	8.9	27	8.5
Agree	246	77.8	235	74.4	255	80.7	262	82.9	266	84.2	267	84.5
Total	316	100.0	316	100.0	316	100.0	316	100.0	316	100.0	316	100.0

Source: Students questionnaire. Both teachers and students (100%)agreed that they did not do any other topic through inquiry

The interpretation here was that although the syllabus stated a number of projects that the students should do and even suggested that the list could be expanded, teachers hardly provided any opportunity for their students to carry out chemistry projects. The reasons for most students doing a project on soap preparation were not given.

Factors that Hinder Extensive use of Projects in Teaching Chemistry

Using the teachers' self assessment questionnaire, the author sought information pertaining to the factors that hinder extensive use of Chemistry projects in schools. From the results, five key factors were identified. Close to thirty-two percent of the sampled teachers indicated that projects assessment marks were not included in the final grade; slightly over 28% indicated that they lacked time to undertake the projects; slightly over 21% indicated that their main challenges was lack of resources and equipments; close to 14% indicated that there was inadequate Chemistry teachers, and slightly below 4% indicated that some of them were un prepared to undertake projects.

Discussion

The findings that Chemistry teachers do not use inquiry learning to the extent stipulated in the syllabus underscore the need for teachers to ensure that learners are given adequate numbers of inquiry learning sessions in order to enhance understanding. This then would be consistent with the views of Gage (1962), that lab experiments are more effective than other methods of teaching Chemistry, as they enhance understanding and appreciation of the subject. The view is supported by Grasha (1996) who says that the use of inquiry learning as stipulated in the syllabus offers an alternative learning style that influences a student's ability to acquire information, to interact with peers and the teacher and otherwise participate in learning experiences. Blackmore (1996) echoes these views in suggesting that one of the first things that educators can do to aid the learning process is to simply be aware that there are diverse learning styles in the student population.

Use of inquiry learning as stipulated is in concurrence with the needs and requirements of the curriculum. The finding that the teachers did not use inquiry learning as stipulated is therefore consistent with the views of Onnka (1985) and Ughamadu (2005), that no matter how well developed and comprehensive a curriculum is, its success is dependent on the quality of the teachers implementing it. Mamlock (1998) and Rannikmae (2001) contend that it is important that teachers develop methods of student centre teaching and teacher ownership if teaching is to be meaningful for students.

The study also established that the major factor hindering implementation of Chemistry inquiry learning was the fact that marks awarded for inquiry learning were not carried forward to the final examination grade. Lack of time due to the congested syllabus was also established as a factor that strongly hinders implementation of Chemistry inquiry learning as stipulated in the syllabus. Other notable challenges identified included lack of resources and equipment; inadequate qualified Chemistry teachers; and ill preparation.

These findings are consistent with those of Linn (1992), that teachers' attitudes have a strong influence on students' attitudes. If teachers approach Chemistry in an overly strict, formal manner, students are likely to lose enthusiasm for the subject. If they make disparaging remarks about students' abilities, these are likely to repel students. These views support those by Keeves and Morgenstern (1992) that students'

anxiety towards the learning of Chemistry makes them lose interest in the sciences in general. As observed by Berdonosor *et al*. (1999) and Eddy (2000), that students consider Chemistry a problematic science is indicative of the chemophobia in a college classroom. It is therefore necessary to look critically into the value of collaboration through inquiry learning which has been overlooked, and this paper shows that such cooperation can have far reaching benefits for all the stakeholders in Chemistry education.

Conclusion and Recommendations

From the findings of the study, the author arrived at the following conclusions: With regards to use of inquiry learning as stipulated in the Chemistry syllabus, the study established that both teachers and students were in concurrence that the Chemistry teachers did not use inquiry learning to the extent stipulated in the syllabus. The study established that the commonest topics learned through inquiry included investigating plant extracts and using them as acid/base indicators, determination of the amount of oxygen in water, identification of common pollutants of water from local sources, atomic model construction, investigations of materials in terms of their structure and bonding, construction and use of fire extinguishers and soap preparation. The study further established that the major factor hindering implementation of Chemistry teaching through students‘ inquiry was the fact that marks for such activities were not carried forward to the final examination grade, lack of time due to the congested syllabus, lack of resources and equipment, inadequate qualified Chemistry teachers and ill preparation.

From these conclusions, the following recommendations are made to enhance the use of inquiry learning in secondary school Chemistry teaching/learning in Kenya:

- Chemistry teachers and government should follow the specifications in The National Chemistry Syllabus Curriculum.
- Chemistry teachers need to develop theories together with instructional materials that are useful in classroom practice.
- It is therefore recommended that Chemistry curriculum designers, teacher educators and teachers working together on specific chemistry inquiry learning topics, to bring in and exchange specific knowledge, and to built up new

knowledge. This will help teachers to articulate research questions that are relevant, open for answering under realistic conditions of time and money.

- There is need for provision of standard and well-equipped chemistry laboratories, exposure of students to practical chemistry right from Form 1 and organization of excursion and fieldtrips for more exposure. Serious attention should be given to all these as they will further enhance the interest of the students in the subject.
- The frequency of small group tutorial sessions and discussions must be increased.
- The exploratory approach through experimentation must be used more frequently.
- The students should be provided with more learning aids.
- Successful teaching and learning of chemistry depends partly on correct use of a teaching method whose activities target most learning senses.

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