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RESEARCH ARTICLE

NATURE OF INTERACTIONS DURING LABORATORY TEACHING AND LEARNING OF SECONDARY SCHOOL SCIENCE BY TEACHERS AND STUDENTS IN KENYA

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Abstract

The natural sciences are highly regarded subjects in the Kenya science curriculum. This is due to the fact that the country hopes to use scientific knowledge to enhance development of industries and propel the country to achieve vision 2030. However, the performance of students in science examination has not been impressive, especially in questions that require science process skills usually acquired from the laboratory. The study, therefore, sought to explore the nature of interactions during laboratory teaching and learning set up by the teachers in a secondary school in Kenya. The study adopted a qualitative approach. It involved three science teachers, six students and three classes. The study used qualitative data collection methods namely; laboratory observations, semi-structured interviews, focus group discussions and document analysis. Data analysis involved organizing, coding and analyzing data as well as interpretation. The findings of the study indicated that the teachers used group-based laboratory activities to enhance a variety of interactions. The pedagogical implication of the findings is that the nature of interactions hinder student understanding of scientific concepts and development of scientific process skills. This therefore compromises students' attainment of scientific literacy and may lead to poor performance in science examinations. Consequently, it is imperative that teachers adopt teaching approaches that would enhance students' scientific literacy, through appropriate use of laboratory interactions.

Introduction

There is a lot of emphasis both globally and in Kenya about scientific literacy (Ogunmade, 2005; Government of Kenya, 2008). Scientific literacy is often recognized as the knowledge of significant science subject matter, the ability to apply that knowledge and understandings in everyday situations (Dani, 2009). The emphasis on scientific knowledge is based on the role this knowledge plays in personal and national development (Laugksch, 2000). Laugksch (ibid.) argues that at a personal level, scientific literacy enables people to make the best decisions possible with regard to health, energy, natural resources, food and the environment they live in. These decisions affect individuals, their families and the wider community. At the national level scientific literacy may determine the pace of industrial and technological development. Consequently, there is need for every individual and the society to be scientifically literate. Indeed, as Millar (2004) argues, the 21st century requires people who are more knowledgeable in scientific and technological issues, views supported by Hobson (2008) who posits that scientific literacy is the lifeline for industrialized democracies.

However, scientific literacy can only be achieved through quality science teaching which focuses on teaching for conceptual understanding of both science content knowledge and process skills using available resources. The drive for achievement of proficiency in scientific literacy has made many countries in the developed world to develop science curricula whose focus is to equip learners with knowledge and skills that would promote scientific literacy. For instance, the US government through the National Research Council and the American association for the advancement of science has focused on improving the curriculum of K-12 classroom so as to enhance scientific literacy (Foster & Shiel-Role, 2011).

In appreciating the global importance of scientific literacy, the Kenya government linked the achievement of scientific, technological and industrial development goals of vision 2030 to sound teaching of science (Government of Kenya, 2007). The government envisages the attainment of Vision 2030 by primarily equipping learners with scientific knowledge and process skills for industrial and technological development which is one of the national goals of education. It is hoped that the attainment of this knowledge and process skills will propel the country to achieve Vision 2030 hence make it technologically more competitive on the international markets. However, sound science teaching that would lead to acquisition of process skills and scientific knowledge requires an appropriate curriculum and provision of both physical and skilled human resource.

With regard to the curriculum, the 8-4-4 science curriculum in Kenya stipulates that science is a compulsory subject in primary school where it is offered as general science and agriculture (Oyoo, 2010; Sifuna & Kaime, 2007). In secondary school, science is compulsory up to form two for all students after which students select at least two science subjects as they proceed to form three regardless of the focus of specialization (KIE, 2005). The curriculum further recommends the allocation of a double lesson every week for laboratory based activities for every science subject so as to enable learners develop scientific process skills. This is based on the belief that frequent laboratory use will not only enable learners acquire scientific process skills but also foster the understanding of scientific concepts.

More importantly, the Ministry of Education Science and Technology (MoEST) has identified the science laboratory as critical in the teaching of science since its use enhances the achievements of the national objectives of teaching science (Government of Kenya, 2005). Consequently, the government provided schools with science equipment besides constructing laboratories so as to create an environment conducive for effective science teaching and learning (Waititu & Orado, 2009).

Besides providing physical resources, the Government has also instituted in-service training (INSET) to strengthen the teaching of mathematics and science in secondary schools (SMASSE) (Nui & Wahome, 2006; Waititu & Orado, 2009). The INSET is based on a baseline survey that showed that there was need to change the teachers' attitudes towards the teaching of science, equip them with appropriate teaching methodologies and boost their content knowledge. It was hoped that by focusing on these three aspects, the teachers would be able to manipulate the science teaching environment (classroom and laboratory) so as to improve students' learning outcomes. The INSETs' main focus is to make teachers embrace 'hands on' and 'minds on' teaching approaches (Nui & Wahome, 2006). These are approaches that require learners to actively participate in learning activities. Such teaching approaches will inherently require the use of the science laboratory.

These interventions are all meant to ensure that science students achieve the requisite scientific knowledge and process skills that they will harness to build a technological society envisaged by Kenya's vision 2030. Despite these initiatives the teaching methods of science in Kenya remains traditionally teacher centred (with limited use of the science labs) which Oyoo (2010) argues does not effectively foster development of scientific knowledge and skills. This teaching approach as argued by Oyoo (ibid.) has been associated with candidates continued poor performance in science in national examinations which is clearly demonstrated in KNEC science results for the years 2008 up to 2010.

Table 1: KCSE- analysis of science results for years 2007-2010

Year	2008	2009	2010
Subjects/mean %	Mean %	Mean %	Mean %
Biology	30.32	27.20	29.23
Chemistry	22.74	19.13	24.91
Physics	36.71	31.33	35.13

Source: KNEC Reports, 2011, 2010 & 2009

The tabulated results show that performance in science has been generally poor. In fact, while releasing the 2011 KCSE results on 1st of March, 2012, the then Minister of Education lamented about the poor performance in science. The Minister blamed the poor performance, particularly in chemistry, on the use of archaic laboratories when conducting practical examinations (Oduor, 2012). This signals the ministry's awareness of the importance of the science laboratory in science teaching and examinations.

Moreover, besides the general poor performance in science, the Kenya National Examination Council (KNEC) reports (2008; 2006) indicate that candidates are persistently performing poorly in questions that require knowledge of scientific process skills. What is more, the same reports show that candidates answer practical questions theoretically. This would most likely mean that they lack the scientific process skills. Process skills are mainly developed in the laboratory. While the inability of the students to answer questions requiring process skills may have been caused by a variety of factors, ineffective use of the science laboratory could be the main contributing factor, since the science laboratory is mainly meant to enhance the development of scientific process skills (Hofstein & Lunetta, 2004). Therefore, it is highly probable that the students may not have been effectively involved in practical activities that would have enable them acquire the process skills. Consequently, there is reason to suggest that probably the science laboratory is either unused or is ineffectively being used.

From the author's experience, both as a science student and as a science teacher, the teaching of science is mainly by teacher demonstration and by lecture method. This resonates with various researchers' observations that science teachers teach theoretically even when laboratory facilities are available (Omollo, 2009; Oyoo, 2010; Sifuna & Kaime, 2007). These researchers argue that demonstrations and lecture methods of teaching science do not effectively foster development of scientific process skills, views which the author concurs with. Yet, the Kenya Certificate of Secondary Education (KCSE) places a lot of emphasis on scientific process skills whereby in the practical examination paper one has to score at least 30% in order to get grade B- and above in the national examination (KNEC, 2005). Indeed, KNEC (2008; 2010) reports recommend that teachers should allow students to carry out practical investigations by themselves so as to develop creative thinking and scientific process skills.

It should be borne in our minds that if students continue missing the scientific process skills, it will firstly compromise the country's objective of developing a scientifically literate society and more importantly, it will jeopardize the country's Vision of attaining scientific, technological and industrial development by 2030 since it is hinged on scientific literacy.

Since learning environments influence student learning outcomes (Wang & Lin, 2009) and the laboratory is an important learning environment with regard to development of science process skills (Hofstein, 2004), and yet students have been performing poorly in questions that require knowledge of scientific process skills, despite the increasing government's investment in science laboratory infrastructure, there was need to explore how science teachers use the science laboratory in facilitating students' science learning since effective students' learning will ultimately lead to attainment of scientific literacy.

Scientific Knowledge

Literature shows that scientific knowledge is conceived both as a product (content) and as a process (Flick & Lederman, 2004**)**. As a product science consists of empirically proven but tentative knowledge in form of abstract ideas, concepts, theories and laws (Bell & Lederman, 2003). It is this knowledge that teachers aim to make accessible to learners during instruction.

On the other hand, as a process, science is seen as a way of knowing (Staver, 2007). This means that science is a method of gaining information and generating scientific knowledge (Bell, 2009). In order to gain this information one must follow a standardized procedure-the 'scientific process' which involves observation, questioning, hypothesizing, experimentation, recording data, interpretation and making conclusion.

The understanding of these two domains of scientific knowledge is important in teaching science since it influences how science is taught. If science is viewed as a product it will be presented as a rigid body of knowledge which students only confirm. However, if science is viewed as a process teachers will teach by involving learners in investigations (Bell, 2008). According to Harlen (2004), investigative teaching approaches are more likely to help learners develop a better understanding of the natural and the man-made world. Learners who have a better understanding of the world are likely to be more productive in the society. Perhaps this explains why the MoEST recommends knowledge and process skills should be taught together and not as separate entities (KIE, 2005). The MoEST believes that by integrating theory and practical students will be able to understand the nature of science hence contribute productively in the society. It is envisaged that integration can be achieved if teachers employ a variety of teaching approaches such as; teacher/learner discussions, teacher demonstrations, class experiments and project work.

This recommendation by the MoEST on how science should be taught makes the laboratory very important in the teaching and learning of science since the lab provides an ideal environment for teaching using the stated approaches. Secondly, the recommendation resonates with current constructivist trends in science teaching. Constructivists view teaching science as a process where teachers facilitate learners' own internal process of constructing new understanding (Driver, Asoko, Leach, Mortimer & Scott, 1994; Glaserfeld, 1982; Staver, 2007). Consequently, teachers should consider how learners construct their own knowledge and acquire scientific process skills from provided learning experiences (Brown, 2004). This paper, therefore, aims at understanding how science teachers use the laboratory in order to make learners acquire both content knowledge and process skills in an environment where current teaching and learning trends is constructivist.

Learning of Science

The concept of learning is understood differently by different people depending on the epistemological stance one subscribes to. For instance, behaviourists see learning as behaviour modification, cognitivists focus on the mental processing of information, human psychologists see it as personal growth and development while social-constructivists define it as developing new conceptions and construction of reality (Brown, 2004). This paper takes the social-constructivist view of learning that knowledge is socially constructed. Consequently, the study was guided by the assertion by Leach and Scott (2000) that learning science is to be introduced to the ways of thinking and explaining the world using the tools of the scientific community. This would mean the process of introducing learners to the scientific process of learning by enabling them interact with the learning environment and materials. Interaction with the learning environment and materials will enhance a clear understanding of the scientific concepts.

Research shows that social constructivists believe that the development of new knowledge requires interactions among learners as well as between learners and their facilitator as they manipulate the new information (Driver, Asoko, Leach, Mortimer & Scott, 1994). In a classroom scenario the teacher as a facilitator acts as the more knowledgeable other. However, facilitation by teachers largely depends on their view of learning. Generally there are two broad views of teaching and learning science; teachers who view learning as knowledge acquisition and see themselves as ‘experts’ hence teach by transmitting knowledge to learners mainly through the lecture method (Prince & Felder, 2006) or the expository lab activities (Llewellyn, 2005) and those who view learning as knowledge construction and thus help learners construct personal knowledge based on their prior experience and interaction with the learning environment (McLoughlin & Taji, 2005).

Accordingly, their teaching is characterized by learner-centred teaching strategies that emphasize interactions within the learning environment and the teacher acts as a facilitator (Gilbert & Treagust, 2009; Prince & Felder, 2006). This teaching approach is typical of constructivist teaching as observed earlier and the science laboratory would be the ideal place since the science laboratory is meant to provide learners with the opportunity to interact with both content and each other as well as manipulate the science equipment.

Literature in the developed world about teaching science have shown that laboratory instruction plays an important role in the development of scientific knowledge (Hofstein & Lunetta, 2004; Hosftein, 2004). However, little is known about how the laboratory is used in the teaching of science in East Africa, the context of this study. The few studies available (Oyoo, 2010; Nui & Wahome, 2006; Waititu & Orado, 2009) have focused generally on the teaching of science. Their findings show that the teaching of science is mainly by transmission. This teaching approach limits learners’ acquisition of scientific knowledge thus leading to poor performance in national examination. However, none of these studies have specifically focused on laboratory use in science teaching. Yet, if the laboratory is effectively used it may significantly contribute to understanding of scientific concepts. Moreover, KNEC (2006; 2008) reports indicate that learners have been answering practical questions theoretically and performing poorly in questions that require use of process skills.

Although the persistent poor results in questions that require process skills may be caused by many factors, non use or ineffective use of the laboratory is the main cause since the science laboratory is the main environment where practical knowledge and specifically process skills are supposed to be acquired through practical activities. Consequently, there is reason to suggest that the laboratory either is being ineffectively used hence contributing to the poor results. For this reason, a study like this one was justified.

Limitations of the Study

The study focused on how three science teachers in one school used the science laboratory to facilitate students’ learning science. The findings therefore do not include practical activities done in normal classrooms or outside the laboratory. Similarly, laboratory activities done by other science teachers within the lab do not form part of the findings of the study.

MATERIALS AND METHODS

The study was conducted at Ng’omen (pseudonym) secondary school located in Uasin Gishu County in Kenya. Ng’omen is a District public school that offers the 8-4-4 curriculum to both boys and girls. The school has a population of 850 students and a staff of 52 teachers, seventeen of whom are science teachers. Additionally, the school had three fairly equipped science laboratories and has an average performance in the form four KNEC science examinations. The author adopted a qualitative approach. The study also involved interpretation of laboratory use based on a direct observation of science teachers in the laboratory and their description of how they use the science laboratory in science teaching.

Three science teachers, one female and two male, with varied lengths of teaching experiences were purposively selected based on their willingness to participate in the study. One teacher was chosen from each of the sciences, that is, Biology, Physics and Chemistry, because being science teachers they have first – hand experience in using the laboratory when facilitating students' science learning. This was in line with the assertion by Cohen, Manion and Morison (2011) that case studies rely on participants that are likely to provide rich data. Although science teaching approaches are generally similar, observing each science teacher across the classes provided rich data on how the laboratory is used in science teaching.

A total of six students were selected, two from each of the classes taught by the three science teachers. Mixed gender was considered so as to increase diversity of responses during the focus group discussion. When selecting students for the focus group discussion, the author opted for students whom he had identified to be participating actively during laboratory sessions as well as those who were passive so as to ensure that the findings portray a true representation of laboratory use from the perspective of the students. Data from these students was useful in corroborating data from observation of laboratory activities and teacher interviews thus enabling the author get a holistic picture of the nature of interactions.

The observation of laboratory activities was done in form one, two and three. The study utilized several data collection methods namely: laboratory observation, semi-structured interviews, focused group discussions and document analysis. The author conducted data analysis immediately after collecting the data and progressively processed the data by first writing detailed notes of each laboratory observation and documents analyzed. He also transcribed each interview immediately. After writing the complete notes and transcribing all the interviews, he read and re-read the notes and interview transcripts carefully as he replayed each interview record several times in order to ensure that he captured the information accurately. Thereafter, he read and re-read the data as he tried to identify ideas and ascertain the emerging patterns that would be useful in answering the study question.

While referring to the subsidiary questions as his themes he used different colors to code ideas in the data from laboratory observation, interviews, FGD and document analysis. Then he sorted the ideas into emerging patterns within each theme. Finally he interpreted the patterns and organized them into themes, and then he presented the data as a descriptive narrative (Miles & Huberman, 1994).

RESULTS

Data from interviews, laboratory observations, and FGD and document analysis revealed that there were various forms of interactions in the lab: learner to learner interaction, learner to teacher interaction, learner to material interaction and learner to content interaction. All the interactions were group-based and the main focus of the interactions was completion of the laboratory activity and management of the class.

Learner-learner Interactions

Research data collected during this study shows that learner-learner interactions in the laboratory were of two forms; formal and informal interactions. Both types of interactions took place within group settings in the laboratory and the group members were expected to submit group reports hence the need for interaction. Informal interactions involved learners working together without any established individual responsibilities while formal interactions involved identified leaders in the groups conducting the lab activity on behalf of the group in order to achieve the objectives of the set task. The group leaders were chosen by the learners or volunteered to lead the group. Groups therefore appeared to have been the fulcrum of lab activities upon which all interactions were based.

The use of groups was evident in data collected from lab observations, teacher interviews, student focused group discussions and documents analyzed. For example, of the nine lab sessions observed I noted that learners worked in informal groups where they were required to write common reports in seven sessions. However, each learner in the group was expected to have their own record, perhaps for accountability purposes. It is only in two sessions (one Physics, and one Biology) where the author observed teachers demonstrating to a small group of leaders who were in turn expected to lead their respective groups in conducting the group activity. During the Biology lab sessions, the appointed group leaders guided their groups in preparing temporary slides when learning how to use the light Microscope (Observation May 17, 2012), while during the physics session on *Hooke's law* the teacher showed the group leaders how to generate the data and use it to calculate the spring constant (Observation May 18, 2012). These were the formal groups.

Furthermore, it was observed that in all the nine lab sessions, learners freely consulted each other both within and across groups; nonetheless, learners were expected to observe the lab safety rules. For instance, in one Biology session where learners were conducting a practical on *food tests*, the teacher reminded learners to be careful when moving within the lab, so that they do not burn themselves (Observation May, 2012). The author understood this caution as a safety precaution since learners were expected to freely consult yet the room was congested. The free consultations and the fact that learners were expected to write a common report arguably provided learners with the opportunity to interact.

These observations were consistent with what the teachers said during the interviews. For instance, one teacher, in describing teaching in the science laboratory stated:

> I put my learners into groups…although I have no definite groups I ensure that the groups have serious learners and because I know my learners I keep on organizing them to ensure that they work (Interview May 11, 2012).

This explanation suggests that when forming groups the teacher ensured the group members would achieve the objectives of the lab session thus the consideration of 'serious learners'. This implies that the learners were expected to interact. It is highly probable that the serious learners were meant to coordinate the group activity and ensure its success. Coordination would require learner-learner interaction.

Similarly another teacher, while describing his teaching in the lab revealed:

> I use group work mainly….Although I use group work I understand it would be important to have individuals doing the practical ... in fact I sympathize with them because of the numbers, group work doesn't allow proper development of skills yet they are necessary during exams (Interview May 17, 2012).

This excerpt shows that the teacher uses groups to ensure practical activities are done albeit with reservations since he felt that group based activities limited individual learners' acquisition of practical skills.

Data obtained from the laboratory booking sheets demonstrated that the use of group based activities was pervasive since most of the booking sheets indicated practical requirements were mainly meant for group activities. Furthermore, a focus group discussion with the students also yielded similar results. For example, one of the students said: "we usually do our practicals in groups" (FGD May 18, 2012). When probed further to find out how they operated in the group, another student explained:

> While in groups we choose our leaders but in most cases volunteers in the group perform the practical then we agree as a group before the secretary notes the final report. We usually write a common report for marking (FGD May 18, 2012).

This would most likely mean that the students worked in both formal and informal groups and for them to come up with leaders and agree on a common report, the learners arguably would have to discuss; meaning that interaction among them was inevitable. However, this view did not seem to apply to the form ones, since one student objected claiming that in form one, although they worked in groups they were not required to write common reports but each of them was expected to record the agreed conclusions which were finally discussed in class or collected by the teacher for marking.

Furthermore, during the same FGD students were in agreement that responsibilities in groups were rarely shared. This meant that learners interacted informally to complete the laboratory activity and submit a common report. The report was mainly written by the active learners on behalf of the group. Indeed, it was noted that, of the nine laboratory sessions observed, it was only in one session where the teacher facilitated the structuring of the groups by ensuring that every group had a leader and a secretary. So, in all the other eight laboratory observations the group operations were left at the discretion of the members as long as they accomplished the session objectives. The author also observed that group sizes seemed to be dictated by the apparatus set for a particular activity, consequently, group sizes varied from one practical to another.

This data obviously indicate that teachers engage learners in group activities during lab sessions. However, the reasons for engagement greatly differed between the students and the teachers. While some of the students felt that group work was used so that they could support each other, others felt it was meant to avoid breakage of apparatus by those who were less competent in handling them. On the contrary, the teachers cited large classes and shortage of some facilities as the reasons for using group activities. This could imply that the teachers used group based activities as a class management strategy since from observation it was confirmed that the classes were indeed large.

From the foregoing discussion, there is reason to believe that teachers mainly organized lab activities in groups in order to enable learners to successfully undertake lab activities and to make the class manageable. The success of the lab activities depended on learner communication within the group so as to generate a group report. It therefore implies that the learners interacted among themselves.

Learner-teacher Interactions

The data showed that teachers and learners freely interacted during the lab activities. In most of the sessions observed, it was noted that apart from arranging the practical tasks and availing the apparatus, the teachers moved round helping learners follow procedures or set up apparatus. For instance, during one of the Biology laboratory sessions the teacher went round helping learners set up their Microscopes in order to make clear observations. It was also observed that learners freely consulted their teachers whenever they were having difficulties during laboratory activities or to confirm answers. This implies that the learners interacted with their teachers.

Additionally, it was observed that learners were free to ask questions at the end of the sessions. For example, in one of the sessions a learner asked the teacher why the value of their spring was high yet they had followed the correct procedure in calculating the gradient of the curve. On checking the groups work the teacher noted that the learners had not changed the units during calculation. The teacher proceeded to show them the correct procedure (observation notes May 18, 2012). This interaction enabled learners to achieve the objective of the laboratory activity. However, the fact that learners were not asked to explain how they arrived at their answer could imply that the teachers focus was mainly obtaining the correct answer.

These observations are supported by the teachers' response to questions on their roles during lab activities. One teacher strongly stated: "I walk around with the technician correcting those students who are having difficulties, so that they don't get into accidents or get unexpected results" (Interview May 21, 2012). This implies that his interaction with learners serves two purposes; supporting them to successfully complete lab activities and ensuring learners safety.

A similar view was also expressed by another teacher, when he stated:

> I play multiple roles checking apparatus and organizing groups, ensuring set ups for every group is working. I also demonstrate to learners when necessary. I sometimes move round marking students work" (Interview May 17, 2012).

The teacher's description of his role during lab activities indicate that the learners and the teachers interacted when tackling learners' challenges, a view that was also expressed by one of the students during the focus group discussion, she said '…..may be for example, if you are mixing reagents and you are not sure you ask the teacher to confirm' (FGD May 18, 2012), which seems to imply that teachers were available to guide learners to successfully complete the lab activity.

Furthermore, in two of the sessions observed, it was noted that the teacher demonstrated the activity to a small group of learners who would in turn lead the others on how to conduct the practical. For instance, while conducting the session on *Hooke's Law*, a teacher demonstrated how the data for calculating the spring's constant was generated (Observation May 18, 2012). This was also a form of interaction, though limited to the teacher and a few students.

In conclusion, this data suggests the existence of teacher-learner interaction. The exhibited interaction served two purposes; support for learning as seen in provision of activity requirement and checking group progress during activity to ensure correctness of both procedure and results. Secondly, the interaction served as a classroom management tool so as to avoid accidents and ensure successful undertaking of the activity.

Learner to Material Interaction

The data indicate that learners interacted with materials in three ways; through group tasks, small group teacher demonstration and individual tasks within the groups. This conclusion is supported by data from various sources.

The teachers in confirming group based material allocation and teacher demonstrations reported that they allocated apparatus and materials to groups in form one and two primarily because of safety reasons and the fact that the learners were inexperienced in conducting laboratory activities hence may not be able to follow the expected procedures. Additionally, they argued that it enables them move faster in syllabus coverage so that by form three and four they can concentrate on practical in preparation for exams. However, teachers also asserted that in spite of using group-based allocations they encouraged each learner to ensure that they participate in carrying out the practical tasks since learners would perform such tasks alone during examinations. Equally, the laboratory booking sheets showed that teachers mainly plan for group activities signalling that group-based material allocation was the ordinary way of teaching in the laboratory.

Similarly, most learners confirmed working in group based tasks; however, some of the learners expressed disappointment in this approach claiming that it was difficult to access materials in a group as shown by this expression.

> ...the teachers need to let us do practical individually so that teachers can be sure that a person has understood. You see when we are in a group the 'bright' students do the practical and some people just copy what has been done , when the teacher marks he thinks he has understood and yet the person has no content (FGD May 18, 2012).

This means that active students dominated access to materials to the detriment of the passive learners since the groups were not structured. Other learners thought that the use of group work was occasioned by limitation of materials.

Another way in which the students interacted with materials is through small group demonstration. In this approach the teacher demonstrated to a small group of leaders who would in turn lead their groups in conducting the practical. A small number of students therefore manipulated the apparatus as the rest observed. In support of this observation the learners reported that sometimes a teacher asks them to select a leader who will be shown how the practical is done, after which the leader demonstrates to the group. A case in point is a Physics lesson where the teacher demonstrated to group leaders the procedure and the method of calculating the density of water and paraffin using a density bottle (Observation notes May 15, 2012). After which the leaders had the opportunity to show the activity to their groups. The leaders directly interacted with lab materials while the rest of the learners interacted indirectly through observation.

The third way of interaction was observed in form three, whereby although the tasks were group based, learners individually carried out the practical and they were required to write individual reports. The basis for the group arrangement was therefore for easy access of shared equipment and reagents. The teachers argued that, form threes needed to get used to manipulation of materials before the national examination.

In conclusion, the preceding discussion seems to show that learners in form one and two mainly interacted with lab materials by observing active members perform the activity in groups or by observing a group leader demonstrate the activity to the group. However, at form three, in spite of the laboratory tasks being group-based each student had the requisite apparatus to carry out the task.

Learner to Content Interactions

The data also indicated that learners interacted with content at two levels; when discussing the results of the activity in groups and when confirming the outcomes of the practical activity either from the teacher or from the textbooks.

During all the nine practical sessions, it was noted that learners worked in groups as they discussed the interpretation of their findings with reference to textbooks and their notes. For instance, when conducting the chemistry practical on *qualitative analysis* (test for organic compounds), learners kept on referring to an information sheet provided to them by the teacher for interpretation of the results. This observation was confirmed by most of the students as the norm. For example, one student disclosed, “We refer to the text book or ask the teacher whenever we are stuck. We are allowed to come with our note books and text books to the lab” (FGD May 18, 2012).

In support of this assertion, one of the teachers, during the interview, argued that they allowed learners to refer to text books and their notes during practical so that they get used to the correct interpretations. Another teacher agreed by positing that the above practice makes interpretation of lab outcomes easy. Additionally, the three teachers reasoned that since the content related to the practical is usually already covered before the lab activity, allowing learners to access it saves a lot of laboratory time because the learners are able to establish the correctness of their answers themselves.

From this data it appeared that theoretical content was useful in confirming theoretical concepts and interpreting the results of the laboratory activities.

DISCUSSION

One of the key findings of the study is that laboratory interactions were varied. The interactions involved learners with teachers, materials, relevant content and among themselves as they attempted to complete the set tasks. The interactions were centred on group activities. Arguably, if looked at from the socio-constructivist perspective, these interactions could have provided both opportunities and limitations for students to learn science.

First, the need for a group report and the freedom accorded to the students in the lab provided learners with a good avenue for interaction among themselves, since in order to generate a group report learners inevitably interacted. This approach to teaching is consistent with socio-constructivist teaching strategies. Studies (Driver, 2004; Staver, 2007) have shown that learner interactions are an important learner-centred teaching strategy used in science teaching to enhance the process of knowledge construction among learners. Scholars argue that such a strategy provide students with an opportunity to re-structure ideas through feedback from their peers, besides motivating and supporting each other (Llewellyn, 2005; Hertz-Lazarowtz *et al.*, 1984). This is because as learners try to find a common understanding they may be forced to reflect on their own contribution based on the provided feedback (Applefield *et al.*, 2000). These reflective interactions probably may have developed learners critical thinking and social skills which are important skills in science learning.

Secondly, since the tasks were group based and the learners were free in conducting the practical, it gave learners a real opportunity to manipulate the laboratory materials. Literature indicates that manipulation of material during laboratory activities enhances development of manipulative skills (Hofstein, 2004). Development of manipulative skills contribute in fulfilling one very important role of the laboratory; development of scientific process skills.

Furthermore, the presence of the teachers, in all the laboratory sessions, who provided necessary support to ensure successfully completion of the tasks, fulfils the role of a significant other (Schunk, 2009). Arguably, since learning is a product of social interaction the teachers possibly functioned as the more knowledgeable others during the lab activities. Thus, they scaffold students whenever they faced challenges, besides ensuring safety in the lab. Indeed, learners revealed during the FGD that teachers supported them whenever they were stuck. Additionally, the need for a group report meant that learners had to interpret the outcomes of the lab activity. Interpretations could have been based on three sources; learners own prior-knowledge, the teachers' views and information from text books.

The use of theoretical content in text books is significant because scientific knowledge is both a process and a product. Indeed, Anderson (2003) posits that theoretical content is useful in learning since it enables students to process information at abstract level. The opportunities for clarification and interpretations provided for in the lab probably enabled students reconcile theoretical content and practical experience.

However, although the teachers might have achieved the objectives of having learners complete the set tasks and write a common report, the author feels that the purpose of interactions in science laboratories, which is usually to provide support for knowledge construction (Mcloughlin & Taji, 2005) was probably not achieved because the group operations were not structured. According to Staver (2007), effective learning of science occurs in a structured environment. Staver (ibid.) further contends that group structuring increases learner accountability. When learners are accountable to the groups, their level of participation increases and this may foster interactions hence learning.

In the study, it was evident that since the groups were not structured and responsibilities not shared interactions were inevitably restricted to a small group of active learners. Consequently, lack of group structures might have compromised the possibilities of students constructing knowledge together, which is contrary to the role of the lab as an environment conducive for knowledge construction (Ozay & Ocak, 2009). It is also contrary to the purpose of group based learning activities as elucidated earlier. This could mean that teachers used group based activities as a class room management strategy and not to enhance learner interaction.

Secondly, in spite of the freedom to consult the teachers, interactions remained limited to a few active students. Moreover, interaction with the teacher was limited to provision of equipment, monitoring procedures, besides ensuring that learners got the right outcomes. Although as argued above the active learners may have developed some scientific process skills, the support provided by the teachers may not have been adequate to enable learners construct their own knowledge as is expected in a constructivist learning environment. Constructivists argue that for effective teaching of science, the teachers must aim at supporting learners to construct their own knowledge (Gilbert & Treagust, 2009). This support would be through mental engagement of learners as they interpret and reflect on their activity outcomes. However, since learners were not encouraged to share their views after completing the task, it is possible that learners did not get the chance to interrogate their prior understanding in order to bridge the gap between their prior understanding and the new information.

Consequently, most learners may not have developed a deeper understanding of their findings. It can therefore be argued that the teachers' supportive roles were ineffective in fostering students' construction of knowledge as well as in utilizing the laboratory environment to enhance learning. The role played by teachers was consistent with previous reports and studies on science teaching in Kenya where teaching was reported to be mainly by teacher transmission (Oyoo, 2010; Waititu & Orado, 2009).

Additionally, since the classes had many students, access to learning materials was nearly impossible hence compromising most learners' development of manipulative skills. Indeed a student complained of accessibility to materials being difficult because of the large classes. Although such learners indirectly got exposed to scientific process skills by observation, it is unlikely that given a chance they would be able to conduct the practical. Given contexts like Kenya where large classes is a reality teaching science using group based activities will need serious planning.

Given that the main purpose of lab interactions is to enable learners actively construct own knowledge and develop scientific process skills and yet the teachers used unstructured groups and offered limited support, it is highly unlikely that this would happen. Secondly, the teachers' use of unstructured groups, yet all activities were group based could imply that they may not be aware of the inherent value of group interactions in teaching and learning science. Thus, there is need to find out the teachers' views on use of group activities in science teaching.

CONCLUSION AND RECOMMENDATIONS

The findings of the study show that the science teachers use the science lab mainly to illustrate theoretical content. This approach is ineffective in enhancing learners understanding of scientific concepts and development of scientific process skills. It therefore compromises students' attainment of scientific literacy. For Kenya, that is aiming to be a newly industrialized nation by 2030 it is unlikely that this goal will be attained. Consequently, it is imperative that science teachers be cognizant of the importance of the science laboratory in science teaching.

The teachers created opportunities for a variety of interactions for learner during laboratory instructions; however, lack of proper group structuring and support meant that the teachers' current use of the laboratory may compromise learners' development of scientific literacy. Although they might not necessarily perform poorly in national examinations, there is no doubt that they will have a limited understanding of scientific knowledge and scientific process skills. Consequently, their contribution to industrial and technological development will be limited. It is therefore imperative that teachers adopt laboratory teaching approaches that would enhance students' development of scientific literacy, such as, creating opportunities for learners to construct knowledge through structured interactions.

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