A MULTI-SITE ANALYSIS OF SECONDARY SCHOOL CHEMISTRY TEACHERS' PRACTICES AND EXPERIENCES FOLLOWING PROFESSIONAL DEVELOPMENT IN KENYA

by

JUSTUS OKEO INYEGA

(Under the Direction of Norman F. Thomson)

ABSTRACT

Kenya models her teacher education on western countries' education systems. More recently, non-western industrialized countries have started to collaborate with Kenya on science education. From July 1998 to June 2003, the Government of Kenya with assistance from the Government of Japan, through Japan International Cooperation Agency, started to strengthen the teaching of secondary school chemistry through a cascade teacher education pilot project. In collaboration with the education officials, principals' associations, and parents associations in the pilot districts, the project was planned, implemented, administered, monitored and evaluated from the headquarters in Nairobi.

In this multi-site qualitative research case study, I examined multi-site cases of teachers' practices and experiences about the chemistry unit lesson planning and implementation following the in-service teacher education program in Kenya. In this study, a descriptive comparison was made of chemistry district educators in the Strengthening of Mathematics and Science in Secondary Education (SMASSE) Project in-service program in four different school settings (boys' boarding, girls' boarding, mixed boarding, and mixed day). The intent of this study was to determine what changes, if any, teachers made in the design and implementation of their lessons, how these changes were implemented, and why the teachers made such changes. The participants used a new lesson plan format. They planned, prepared and implemented student-centered activity lessons. They greatly improved their teaching skills and were able to improvise teaching/learning equipment during their chemistry unit lessons on the Periodic Table, “mole concept”, electrochemistry, and organic chemistry.

INDEX WORDS: Chemistry unit lesson planning and implementation, Electrochemistry, In-service Science Education, Kenya, “Mole concept”, Organic chemistry, Periodic Table, Professional development, SMASSE Project, Teacher practices and experiences.

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DEDICATION

In loving memory of my beloved elder brother, Engineer Evans Intabo Inyega, who passed away at the time I was writing my dissertation. He was, and will always remain, the greatest source of inspiration in my academic and professional work.

(Ase okomoinyora oyominto omwanchwa nyagosira omoinchinia Evans Intabo Inyega obete ogotonyoora engaki nare koriika egasi eye ya'masomo ane. Nigo arenge esiro ase amasomo ane na obwarimu bwane. Nyasae amobeke agaya goika engaki torarorane naende.)

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CHAPTER 1

INTRODUCTION

Background

Prior to and at independence in 1963, Kenya had three different types of education curricula: Education for Whites, Asians, and Indigenous Africans (Eshiwani, 1993; Sifuna, 1990). The education system for the Whites and Asians was advanced compared to that for the Africans, which was mostly managed by ("untrained") missionaries and only offered basic reading skills, catechism and vocational skills (Thomson, 2002). According to Sifuna (1990), the teachers implementing these curricula were educated, employed and paid by different bodies (county councils, religious bodies, independent African schools' organizations, and the colonial government). After independence in 1963, the education system was harmonized through national curricula for public schools and teacher education colleges (Ominde Report, 1964). Because of teacher shortages, emphasis was put on pre-service teacher education and upgrading of “untrained” teachers through in-service education programs conducted by government-sponsored colleges. In this regard, primary school science teachers were educated in primary teacher education colleges, while secondary school science teachers were educated at Kenyatta College, The Kenya Science Teachers' College, The University of East Africa (Makerere) in Uganda, and later, The University of Nairobi (Thomson, 2002).

Since independence, Kenya has made tremendous progress in science teacher education programs and in establishing more teacher education institutions of higher learning (Eshiwani, 1993; Sifuna, 1990). The science teacher education programs (see Calloids, Gottlemann-duret, & Lewin, 1997), however, have been modeled after "industrialized" (western) countries’ education systems (Engida, 2002; Sifuna, 2001). This has had a considerable amount of influence on classroom practices, with little incorporation of local socio-cultural, economic and political perspectives (Cobern, 1998; Gilbert & Yerrick, 2001; Lemke, 2001; Roberts & Ostman, 1998), gender, ethnicity (Bianchini, Cavazos, & Helms, 2000), indigenous languages (Akinnaso, 1990; Bunyi, 1999; Cleghorn, Merrit, & Abagi, 1989; Moje, Collazo, Carrillo, & Marx, 2001; Rollick, 1998), and indigenous science knowledge and technologies of the local people (Engida, 2002; Kesamang, 2002; Thomson, 2003; Thomson & Chepyator-Thomson, 2002). This view is partly supported by the fact that Kenya's official medium of instruction from grade four is in English (Bunyi, 1999), while classroom science textbooks hardly make reference to any indigenous science knowledge in Kenya (Thomson, 2003). There are over 42 different indigenous African languages spoken in rural Kenya (Thomson, 2002), where the majority of the people live, go to school and work (Engida, 2002).

In 1984, Kenya changed her education system from 7-4-2-3 (seven years of primary, four years of ordinary secondary, two years of advanced secondary level, and three years for a basic university degree) to an 8-4-4 education system (eight years of primary, four years of secondary, and four years for a basic university degree). The shift in education policy made natural and some applied science subjects (biology, chemistry, physics, and agriculture) compulsory in all Kenyan public schools (Mackay Report, 1981). The 8-4-4 education's policy found many schools ill-equipped to start science classes coupled with the extra demand for science teachers. In addition, the new education system's high demand for science facilities and teachers hardly gave room for teachers' professional development on how to implement the new curriculum. This has remained so for some time now. Although there was disparity in the provision of physical, material and human resources in schools (Inyega, 1997; SMASSE Project, 1998; Thomson, `2002), students in Kenya sat for national examinations that are centrally set, moderated, marked and graded (The Kenya National Examinations Council, 1998). According to the Kenya National Examinations Council (1998), students' overall performance in science subjects has been declining over the years. It has been argued that one way of addressing the difficulties students experience in Kenyan science classrooms is through appropriate teaching interventions that can be realized through professional development of science teachers (SMASSE Project, 1998). It is hoped that professional development programs for science teachers will equip teachers with appropriate teaching skills and instructional strategies that are necessary to effectively implement science curricula in schools. One such program started in 1998 by the Kenyan authorities with a hope of strengthening the teaching and learning of science in public schools was a pilot project called "Strengthening Mathematics and Science in Secondary Education (SMASSE)."

SMASSE Project Design

The Kenya Government, with assistance from the Government of Japan as a development partner, through the Japan International Cooperation Agency (JICA), hoped to improve teaching and learning of mathematics and science education in public secondary schools by piloting the SMASSE project (SMASSE Project, 1998). Specifically, the project's purpose was to upgrade young Kenyans' capability in science and mathematics at secondary school level through in-service teacher education programs. The expected project outputs included:

1. Establishing a system of in-service teacher education (INSET) for key educators at SMASSE national INSET center based at Kenya Science Teachers' College, Nairobi
2. Establishing a system of in-servicing teachers in mathematics and science in district (SMASSE) INSET centers
3. Strengthening the role of national and district (SMASSE) INSET centers as resource centers.

The pilot districts' baseline survey in 1998 established that the teaching of mathematics and science was affected by many factors including attitudinal issues, teaching methodology, level of mastery of content by both teachers and students, lack of professional interactive forum for teachers, inadequate development of teaching/learning materials, and administrative factors. The SMASSE Project recognized the need to enhance the quality of teaching in terms of appropriate instructional strategies, assessment, resource mobilization and utilization through in-service "training" (INSET) of practicing teachers (SMASSE Project, 1998).

The project aimed to change teachers' attitudes towards the use of appropriate teaching methods to enhance learning of school science. The teachers used to cover the broad and examination-oriented 8-4-4 science curriculum using traditional teaching methods that are more teacher-centered, in which school science experiments are done according to teachers' instructions. The teachers were always under constant pressure to have their students perform well in the national examinations, partly, because teacher promotions in Kenya are based on students' performance in national examinations in the subjects taught by the teacher. This meant that teachers only covered and coached their students on science topic areas they predicted would be present in the national examination papers (each science subject has two papers, a theory and a practical). Teachers in rural schools argued that their schools were disadvantaged in the provision of science facilities/equipment and resources. To address this discrepancy in teaching science, the SMASSE Project called for student-centered activities coupled with appropriate teaching methods/strategies. During the INSETs, teachers were exposed to various types of student activities such as class discussions, hands-on inquiry-based class experiments, and use of locally available materials to teach science concepts where conventional apparatus are inadequate or not available. The teachers were encouraged to plan for student investigations in addition to their planned class experiments done according to the teachers' laboratory worksheets. The project stressed the use of student-centered activities, experiments, and improvisation (ASEI) in teaching science as one way of enhancing learning. The teachers were expected to prepare their lesson plans based on the ASEI movement. This meant that the classroom practices of the in-service teachers were to reflect the ASEI movement.

It was also hoped that teachers would improve their teaching skills/strategies if they were encouraged to thoroughly prepare their daily ASEI lesson plans and use a variety of teaching aids/methods that promoted student interest and curiosity in learning science. This called for thoughtful planning of lesson plans using various reference materials, and teaching of science topics utilizing thoroughly prepared lesson plans and relating them to local contexts. The in-service teachers were also encouraged to continuously evaluate each step of their lesson plan's implementation in terms of teaching/learning processes. By so doing, teachers were to have continuous feedback on their teaching progress and the difficulties their students were experiencing when covering the planned instructional activities. This continuous feedback was meant to assist teachers to identify areas they needed to improve on when planning teaching/learning activities for subsequent lessons. In terms of lesson preparation and implementation in science classes, the SMASSE Project emphasized **planning** of ASEI lessons, **doing** the teaching using the planned ASEI lessons, **seeing** that the ASEI lessons are being implemented as planned, and **improving** on subsequent lessons based on feedback from previously taught lessons. The implementation of ASEI science lesson plans are based on plan-do-see-improve (PDSI) approach.

The project further developed INSET themes for every year during the piloting period: attitude change in 1999, activity student experiments and improvisation (ASEI) planning in

2000, practice in the classroom in 2001, and student growth impact transfer in 2002. According to the SMASSE Project, ASEI movement was important to the project for lesson innovation. More emphasis was placed on student-centered activities and more opportunities for the students to perform class experiments and where conventional apparatus were not available, efforts were to be made in having experiments that involve improvisation of local resources. This new approach to teachers' preparation of teaching/learning science activities was to be realized through the Plan-Do-See-Improve (PDSI) approach before, during and after classroom instructions. In this context, **plan** refers to careful lesson preparation based on learners' needs and problems. **Do** refers to teaching a science lesson using well-chosen and planned activities. **See** means to assess and evaluate a science lesson at all stages of its development and implementation; and **improve** refers to making use of feedback from the lesson evaluation to prepare better instructional activities through enhanced planning and implementation of subsequent lessons (SMASSE Project, 1998). The project assumed that using ASEI lesson plans and PDSI approach during science instruction in Kenyan schools was one way, among others, of ensuring meaningful mathematics and science lessons leading to scientifically literate populations and labor force.

The SMASSE Project was implemented in July 1998 and was to end in June 2003. The SMASSE Project in-service education programs were not only meant to expose teachers to appropriate teaching strategies and methods in science education, but also to act as a forum for teachers to share their teaching experiences in handling difficult topics during instruction (SMASSE Project, 1998).

Kenya's Ministry of Education, Science and Technology

To understand the development and/or demands for professional teacher development programs in Kenya, a little background of the Ministry directly charged with the responsibilities of running public education is essential. Kenya's public education system is centralized and managed by the Ministry of Education, Science and Technology (MOEST) with the Permanent secretary as the chief accounting officer. The Ministry's administration division is headed by the education secretary, who is a professional, while the quality assurance and standards division, which establishes and maintains educational standards in Kenya, is headed by a director (Figure 1).

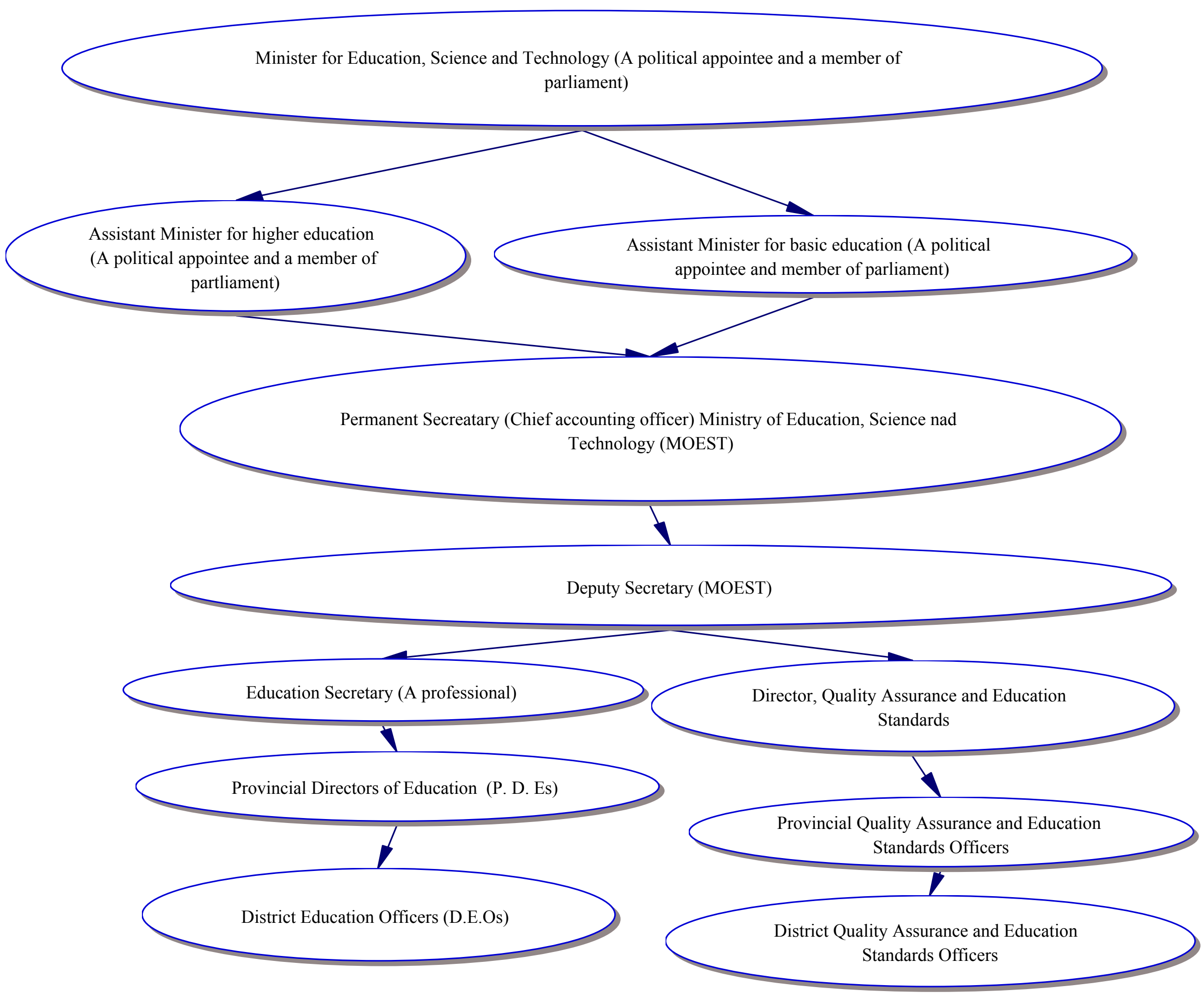
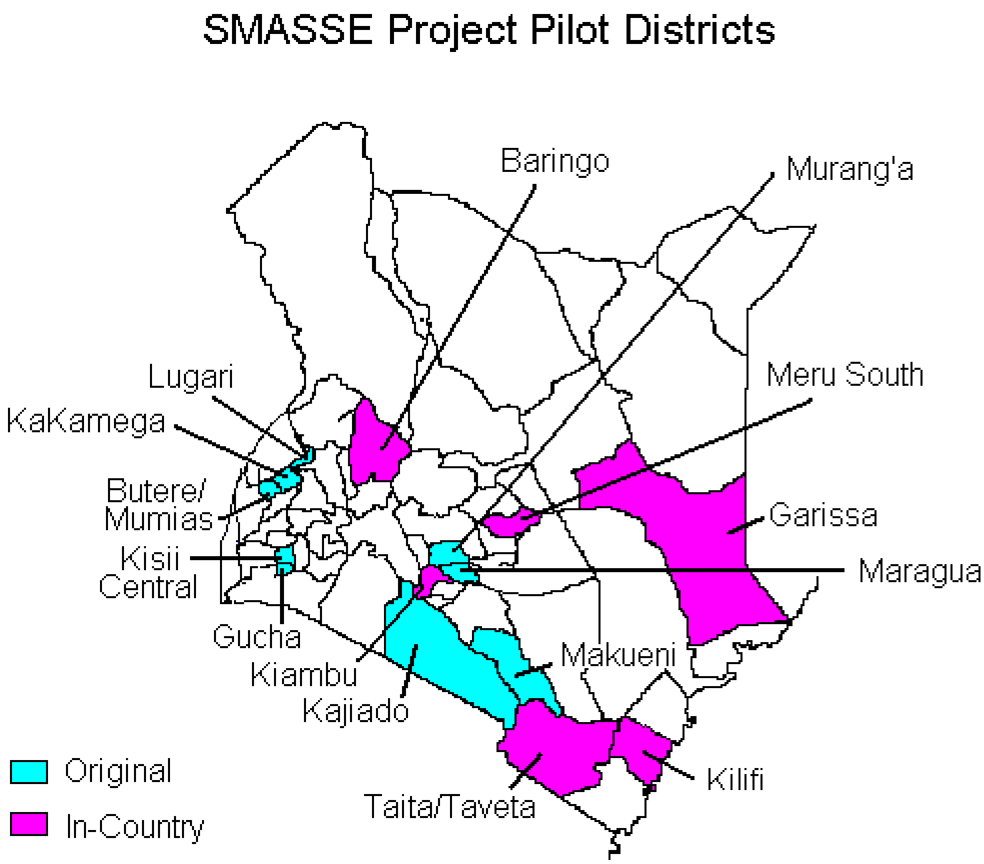


Figure 1. Organizational structure of Kenya's ministry of education, science and technology

Quality assurance and standards officers at the national, provincial or district education headquarters plan, organize, and implement in-service teacher education programs for teachers at various levels depending on the need. The quality assurance and standards officers play an important role in the coordination and running of pre-service and in-service science teacher education in Kenya. In this regard, the SMASSE Project was under the quality assurance and standards division of the MOEST and the director was the national project coordinator.

Kenya has eight administrative (educational) provinces, each headed by a provincial director of education, with a total of 71 districts, and each headed by a district education officer. The districts are further divided into educational divisions, each headed by an assistant education officer. In the field and depending on the promotional grade levels, the quality assurance and standards officers work under the education officers, in-charge of the various provinces, districts, or divisions. In 1998, the SMASSE Project was implemented in nine pilot districts (Kisii, Gucha, Kajiado, Kakamega, Butere/Mumias, Lugari, Maragwa, Murang'a, and Makueni) that are in five provinces (Nyanza, Rift Valley, Western, Central, and Eastern). The education heads in the pilot provinces/districts had a great role to play in facilitating the implementation of SMASSE activities in their respective areas in which they are the official secretaries to the local education boards. In the cost sharing effort, the education boards and head teachers' associations were responsible for the provision of in-service facilities and finances to support the pilot project in their respective areas and meeting the cost of sending teachers to the in-service education centers at the district and national level (SMASSE Project, 1998).



Source: Ministry of Education, Science and Technology, Kenya.

Figure 2. The Pilot Districts for the SMASSE Project in Kenya

Key: Nine (9) Original SMASSE pilot districts (in 1998 to 2003)

Six (6) In-country SMASSE pilot districts (in 2000 to 2005)

The pilot project was to in-service science teachers using a cascade system. Initially, four senior teachers in each subject (biology, chemistry, mathematics, and physics) were selected from each of the original nine pilot districts (see Figure 2) through interviews and were to be educated at the national In-service Education (INSET) Unit based at the Kenya Science Teachers College in Nairobi. Those educated at the national level were to educate their colleagues at the district level in their respective areas. The outcomes of the five-year SMASSE Project were to be used to assess whether it was possible to start all year round national in-service courses for science teachers by the end of the project period in June 2003.

The project continued to monitor and evaluate INSET activities in the pilot districts throughout the project period (SMASSE Project, n. d). On the other hand, experts from Japan conducted mid-term and final SMASSE Project evaluations. Based on the project recommendations, the Kenya Government agreed to start national in-service programs for mathematics and science teachers (the second phase of SMASSE Project) starting May 2003, in which Japanese counterpart personnel would continue to work in the project for the next five years (SMASSE Project, n. d). However, there were no independent studies done by local Kenyan science teacher education experts (not involved in the project), or other non-Japanese external experts, to ascertain the extent to which the project had achieved its objectives in relation to Kenya's needs and context. In addition, there were no independent studies done to establish teachers' experiences and classroom practices following the first phase of SMASSE in-service education programs. Against this background, there was need to determine the teachers' accounts of practices and field experiences concerning how they designed and implemented their chemistry lessons following SMASSE Project educator sessions organized by the national INSET Unit.

Statement of Problem (Need)

Since independence, Kenya, with the assistance of development partners from "industrialized" countries, has tried to enhance its education system through planning and implementation of curricula appropriate to the country's situation (Sifuna, 2001). However, with the inception of a new practical-oriented national science curriculum in all Kenyan public schools in 1984, students' overall understanding of scientific concepts seemed to decline each year as evidenced in their performance in national examinations (The Kenya National Examinations Council, 1998; SMASSE Project, 1998). For instance, candidates in national chemistry examinations are tested using two theory papers (233/1A and 233/1B) and one practical paper (233/2). According to the Kenya National Examinations Council (KNEC) Report released in 1998 for the 1996 examinations' results, the following analysis summary was given (see Table 1).

Table 1

Overall Performance in Chemistry Paper, 233, marked out of 140, for the Years 1993 to 1996.

Year	Entry	Mean Score	S.D	Grade A-	Grade B-	Grade D+
1993	51,897	43.64	21.29	1402	6200	24,934
1994	59,056	44.87	20.49	1729	7285	28,099
1995	61,209	43.12	21.39	1665	7466	28,472
1996	72,140	35.36	19.09	1286	5798	24,757

Source: KNEC (1998)

The table shows that the number of candidates in chemistry has been increasing. The mean marks are low with a drastic drop in performance from 1995 to 1996 as shown by the mean score of 43.12 to 35.36, respectively. The decline in students' performance is also indicated by the decrease in the number of candidates who scored grade A- and above from 1729 (in 1994) to 1286 (in 1996), while the number of candidates increased from 59,056 to 72,140 over the same duration. The students' decline in performance in national science examinations may, however, be attributed to, among others, an overloaded curriculum, disparity in provision of science facilities, schools' administration (Inyega, 1997), type of teaching methods, inadequate professional development programs, mastery of English language, inadequate human resources, type of school science text books, and western world context-oriented examinations (Thomson, 2002). The trend in decline of student performances in the national science examinations at secondary school level was of major concern to all stakeholders in Kenya. This trend prompted the Kenya Government, in collaboration with the Government of Japan, to start addressing students' poor performance in national examinations through the five-year in-service teacher education pilot project with effect from July 1998 (SMASSE Project, 1998). The SMASSE in-service programs were to equip teachers with relevant and appropriate teaching strategies and methods to improve students' learning of school science concepts. Emphasis was put on student-centered science teaching/learning activities, lesson planning, design and implementation of science lesson plans that incorporate new teaching/ and learning skills and strategies. By November 2001, 3200 science/mathematics teachers had been educated with 180,000 students directly gaining from the project (Daily Nation, November 5, 2001). These numbers were expected to increase in the coming years.

The baseline studies conducted by the Chemistry SMASSE Project team in Kenya (SMASSE, 1998) indicated that students had difficulties learning the "mole concept", electrochemistry, the periodic table, and organic chemistry. Many teachers and students from whom data were collected have indicated that the "mole concept" was one of the most difficult topics to teach or to learn in school. Based on these four major topic areas, the SMASSE Project prepared a four-year in-service curriculum for the chemistry teachers. The education was to be completed during school holidays and during the school term period and teachers were expected to practice what they learned at the INSETs in their respective schools. The SMASSE national educators planned follow-up activities that were meant to share ideas with the in-service teachers in the field. The INSET organizers and implementers assumed that science teachers educated at the national level were to be able to educate their colleagues at district level, with continued assistance from the national INSET unit center in Nairobi in terms of follow-up activities, and monitoring and evaluation of the project outputs. By so doing, it was assumed, further, that teachers would be able to transfer what they learned during their professional development sessions into the actual classroom situations in their respective schools in order to enhance their students' capability in science education.

The SMASSE Project educated chemistry teachers were, therefore, expected to change their attitudes of using traditional methods of teaching chemistry to those of applying new pedagogical strategies/approaches through hands-on/minds-on and inquiry-based activities in teaching their secondary school chemistry classes (SMASSE Project, 1998). This required appropriate and adequate preparations in planning, designing and implementing lesson plans that involve student-centered activities and the relevance of the chemistry being learned to their everyday life experiences. The SMASSE project assumed that where conventional apparatus for experimental work were not available in school, the in-service teachers would improvise teaching materials using locally available resources.

The in-service teachers worked under various settings in public schools that involve interaction with other stakeholders in education like parents, students, colleagues, school community members and local education officers. Such interactions are likely to influence the way the teachers prepare and conduct their science classes following in-service education programs. The relationships and interactions among the major stakeholders and processes in education in Kenya are summarized in a conceptual model developed by the author (Figure 3).

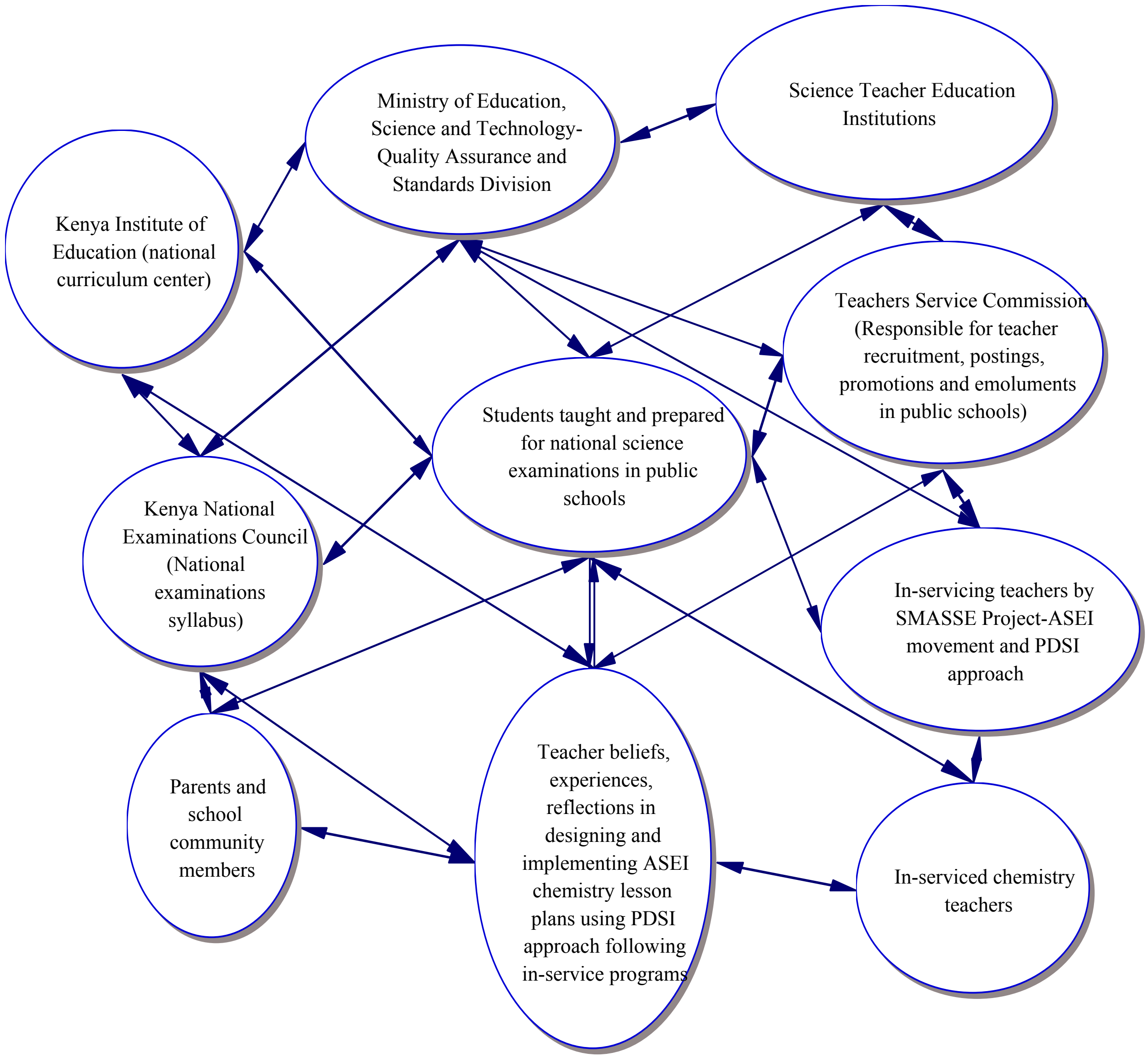


Figure 3. Conceptual model of in-service teachers' relations and interactions with education stakeholders and processes

Key: The double edged arrows (←→) represents the interactions and relationships between the education stakeholders and processes. For example, the Teachers Service Commission (TSC) is the employer of the in-service teachers. It makes decisions on the in-service teachers' postings, promotions and monthly salary payments in Kenyan public schools.

From Figure 3, a conceptual model of in-service teachers' experiences can be inferred in relation to the in-service programs, students and their interactions with various stakeholders in schools. Pre-service chemistry teacher education in Kenya is conducted in different teacher education programs in diverse institutions (Diploma colleges and Universities). The chemistry teachers with different professional qualifications (Dip. Sc. Ed., B. Ed (Sc.), B. Sc., M. Sc., M. Ed) are recruited, posted to public schools, promoted and paid by the Teachers Service Commission in Kenya.

The Kenyan public school system has different high school settings in which students are divided by sex and either reside (board) in school or are day scholars: Boys' boarding, Girls' boarding, Mixed boarding, Mixed boarding/day, Mixed day, Boys' day, Girls' day, Boys' boarding/day, Girls' boarding/day. These public schools are categorized into National, Provincial or District schools based on enrollment and level of provision of teaching/learning resources by the government. This also reflects the expected achievement level of the students admitted into such schools.

Different bodies are responsible for the development and implementation of the national curriculum (Eshiwani, 1993; Sifuna, 1990), and the assessment of students (The Kenya National Examinations Council, 2000) in the public schools. The Kenya Institute of Education (KIE) develops national science curricula. It develops and publishes the chemistry secondary school syllabus, goals and objectives. The Kenya National Examinations Council (KNEC) develops and publishes national examinations' syllabi. Based on the national examinations' requirements, KNEC sets and administers high school chemistry theory (minds-on) and practical (hands-on) papers with the help of teachers. The declining academic performance in students' national chemistry examinations after the inception of 8-4-4 education system in 1984 prompted the Kenya government to start taking intervention measures.

The SMASSE Project outputs were to establish In-service Education (INSET) centers at the national and pilot districts, and have them act as resource centers for professional development programs of practicing science teachers in Kenya (SMASSE Project, n. d.). The mid-term and final project evaluations conducted by external experts from Japan, hired by Japan International Cooperation Agency (JICA), indicated that the pilot project objectives had been met. Those experts recommended to the Kenya Government to start a national in-service program for science teachers with continued assistance from JICA. Based on the project recommendations, the Kenya Government agreed to start a national in-service program in May 2003 (SMASSE Project, n. d.). However, no studies have been conducted to investigate teachers' experiences, beliefs and classroom practices in designing and implementing ASEI lesson plans using the PDSI approach following the SMASSE in-service education courses. Teachers were likely to have different post education beliefs and experiences in designing and implementing chemistry lesson plans in their respective schools based on ASEI movement and PDSI approach. Social interactions with colleagues in schools, the school community, and the national examinations were also likely to influence the in-serviced teachers' beliefs about teaching and learning science.

Against this background, there was need to assess the in-service teachers' views about the impact, effectiveness, efficiency, relevance and sustainability of outcomes of the chemistry in-service teacher education program in Kenya after the five-year pilot project that ended in June 2003. Considering teachers' beliefs and experiences in science teaching (Bryan & Abell, 1999; Luft, 1999) and classroom practices (Chiapetta & Koballa, 2002; Crawford, 2000), there was need to conduct studies in Kenya on teachers' practices and experiences in designing, implementing, and reflecting on their chemistry lessons following in-service education programs (Loucks-Horsey, Hewson, Love, & Stiles, 1998; Radford, 1998; Sapovitz & Turner, 2000; Sweeney, Bula, & Cornett, 2001; vanDriel, Beijaard, & Verloop, 2001) as they helped students learn science using appropriate teaching strategies and methods (Lauglo & Narman, 1987; Lemke, 2001).

Purpose of the Study

This multi-site case study specifically investigated chemistry teachers' accounts of their practices and experiences in designing and implementing chemistry lessons after taking all the four courses conducted by the National (SMASSE) In-service Education Unit (INSET) during the five-year period of the SMASSE Pilot Project in Kenya. The specific objectives of this study were to investigate the chemistry teachers' experiences and accounts of their practices in:

1. Designing chemistry unit lessons following the National (SMASSE) In-service education programs in Kenya
2. Implementing chemistry lessons following the National (SMASSE) In-service education programs in Kenya
3. Making changes when designing and implementing chemistry lessons following the National (SMASSE) In-service education programs in Kenya.

In this study, a descriptive comparison of chemistry teachers' experiences and accounts of their practices in designing and implementing chemistry unit lessons following in-service courses was made. The intent of this study was to determine the strengths (satisfiers) and weaknesses (dissatisfiers) of the SMASSE professional development programs and what changes, if any, teachers made in the design and implementation of their lessons, how these changes are implemented, and why the teachers made such changes.

Research questions that guided the study. The following questions were investigated in the study:

1. How do the SMASSE Project in-service teachers design secondary school chemistry unit lessons in Kenya? What influenced their lesson designs?
2. How do the SMASSE Project in-service teachers implement secondary school chemistry unit lessons during instruction in Kenya? What influenced their lesson implementations?
3. What changes in practice did teachers in-serviced by the SMASSE Project make when designing and implementing secondary school chemistry unit lessons' plans in Kenya? Why did they make changes in their lesson designs and implementation?
4. What are the in-service teachers' reflections concerning their experiences with respect to strengths and weaknesses of the SMASSE professional development program?

The Significance of the Study

At the time of the study, there was no documentation of secondary school teachers' classroom practices and experiences in designing and implementing science lessons following the SMASSE Project professional development programs in Kenya. This study is likely to be the first to document the in-serviced secondary school teachers' accounts of their classroom practices and experiences in Kenya following a national collaborative professional development pilot project program. Studying teachers' accounts of their practices following an in-service program is very important as this will inform the stakeholders of the strengths (satisfiers) and weaknesses (dissatisfiers) of a professional development program. Knowledge of an in-service education program's strengths and weaknesses will guide the curriculum and assessment planners to develop and organize appropriate education activities to enhance science teaching and learning in schools.

On the other hand, education development partners from "industrialized" countries, focusing on sub-Saharan Africa, in particular Kenya, are likely to find these study outcomes important for efficient future planning, organization and implementation of pre- and in-service teacher education programs to enhance students' capability in science. These study outcomes are likely to assist the Kenya teacher education planners in developing and implementing national in-service science teacher education curricula. The dissertation will be part of available literature on Kenya's in-service science teacher education programs and classroom practices following professional development experiences.

Constraints and Assumptions of the Study

The study assumed that the in-serviced teachers were self-motivated and their participation in the SMASSE Project in-service teacher education programs was voluntary and in-service courses led to their staff development units' accumulation. The study also assumed that the teachers' initial educational backgrounds from various institutions, promotional grade(s) and teaching certificate(s) did not negatively affect their work output in schools. It was also assumed that the stakeholders in education (principals, parents, politicians, education officials, and school community members) appreciated and supported school science teachers' professional development through in-service teacher education. The study assumed that the in-serviced SMASSE chemistry teachers continued to teach chemistry as they developed professionally; and that the disparity in the provision of science facilities in schools did not affect their effectiveness in teaching.

The research study was done through self-sponsorship thus leading to the researcher's financial constraints during data collection. The financial constraints limited the scope, duration and the number of participants selected for the study. Other constraints in the study were the large distances between some of the study schools and inaccessibility of some of the rural schools during a rainy season.

Operational Definitions

1. Classroom practices	-Refers to curriculum, instruction, learning activities, assessment, and learning environments in schools
2. Lesson plan	-Teacher's guide on teaching/learning activities and methods to be undertaken during class instruction -Teacher's daily guide on instructional activities and teaching/learning skills, strategies, approaches, methods, and organization for each class taught by him/her.
3. Design of lesson plan	-The format a teacher uses in making his/her daily instruction work plan for the teaching/learning activities, skills, approaches, strategies, methods and organization in class -Components a teacher includes in his/her daily work plan for the class he/she is to teach -The way a teacher writes his/her daily instructional work plan for the classes he/she is to teach.

4. Implementing a lesson plan	-Teacher's actual classroom instruction, based on his/her daily instructional work plan for a given class in a given school.
5. In-service teacher education	-Professional teacher development programs.
6. Reflection	-Teacher's experiences and evaluation of his/her lesson design, implementation, student assessment during instruction, and areas of improvement if the lesson were to be taught again or improvements to be made in subsequent lessons
7. Change in science teaching	-Refers to teacher's modified actions towards teaching school science following professional development programs

CHAPTER 2

LITERATURE REVIEW

Teaching and learning of school science call for new and context-based pedagogical strategies. Students' motivation and achievements are enhanced when they are involved in designing activities that help them to think about learning and their environments. This process internalizes values and provides ownership for the learner, while the teacher provides workable activity frameworks (Pearce, 1993). In addition to the more traditional approaches to science teaching, teachers may direct hands-on instruction as starting points for inquiry activities. Carefully administered teaching environment provides opportunities for students to design their own learning (Pearce, 1993).

However, diversity in science classrooms calls for other science teaching approaches. To achieve equity in education, multicultural teaching strategies are required to address diversity issues in science classrooms (Atwater, Radzik-Marsh, & Strutchens, 1994). Teachers ought to be exposed to inquiry and multicultural science education teaching and learning strategies during professional education courses. Keys and Bryan (2001) argued that there is "still very little knowledge of teachers' views about the goals and purposes of inquiry" (p. 636), while teachers, if any, hardly incorporate multicultural science teaching strategies in their science classes (Atwater, Radzik-Marsh, & Strutchens, 1994).

The SMASSE pilot project hoped to increase student achievement in secondary school science through in-servicing of teachers in Kenya. During the five-year SMASSE project duration, the chemistry in-service teachers were prepared on new teaching approaches that focused on student-centered activities, experiments and improvisation in some chemistry unit areas: electrochemistry, “mole concept”, organic chemistry and the periodic table. In this context, one may ask the following questions: What are teachers’ accounts of practices and experiences about these new approaches to science teaching following their in-service programs? What are the teachers’ perspectives about their planning of science lessons following their in-servicing? What are the teacher reflections and experiences about the in-service programs they undergo? These questions are best answered through qualitative research designs that are informed by social constructivist perspectives, and focus on teacher interviews (Kvale, 1996; Mishler, 1986) and observations (Preissle & Grant, 2003).

In doing research from social constructivist perspectives, teachers are seen as acting on things depending on the meanings they attach to them as they interact with others in society. Teachers develop meanings through social interactions and modified interpretive processes in the context of real life situations. According to Crotty (1998), a researcher ought to see things and construct meanings from the research participants' point of view. By so doing, the research process will be more trustworthy, credible, and confirmable (Ryan & Bernard, 2000). The in-service teachers in Kenya interact with teacher educators, colleagues during professional development, students, parents, and school community members in their respective schools. During these interactions, teachers continue to construct new knowledge and meanings (that are modified from time to time in given contexts) on their educational practice through social and interpretive processes.

Theoretical Framework

Social constructivism (Atwater, 1996; Crotty, 1998; Schwandt, 1994; Rodriquez, 1998; Staver, 1998) guided this multi-site research case study. Social constructions of knowledge continue to take place whenever one interacts with his or her environment. As learners interact with their peers and immediate environment, "instruction must take as its starting point the knowledge, attitudes, and interests students bring to the learning situation. Instruction must provide experiences that effectively interact with students' prior knowledge, as the students construct their own understanding" (National Study of Science Education, NSSE, 2000, p. 31). Learners' knowledge is not acquired but made through construction of their own sets of meanings or understandings as they interact within their environment. It has been argued that "learning is primarily a process of assimilation and accommodation to disturbances in the subject's environment" (NSSE, 2000, p. 49), and "language plays a role far more constitutive of knowledge within social constructivism than in individual constructivism" (NSSE, 2000, p. 66). Learning is a continuous process. As learners, teachers continue to develop scientific language, knowledge and skills.

Teachers have opportunities to interact with each other during professional development. Through social interactions within a community of professional science education personnel, teachers are likely to gain considerable practical knowledge about teaching and learning. The teachers are also likely to develop and improve on their scientific knowledge and language, especially when teaching science using English as a second language (Rollnick, 1998).

Individuals construct knowledge within a social structure and through interactions (Atwater, 1996; Schwandt, 1994). Individuals continuously construct knowledge and new meanings as they make sense of their immediate environments. An individual or society's knowledge is not static. Through interaction, an individual shares knowledge with other people within his/her immediate community and wider society. However, each person's knowledge structure is different from others because his/her life experiences and choices uniquely form each individual's knowledge. People sharing similar cultural values and experiences are likely to perceive a given phenomenon in a given setting differently depending on their prior experiences and ways of thinking.

The social context of learning influences the way one constructs new knowledge. Teachers’ interaction and participation in their communities’ cultural activities facilitate acquisition of new knowledge through practical experiences. Social constructivism takes into account one's contribution to meaning and learning through individual and social activity (National Study of Science Education (NSSE), 2000). Social constructivism is important in teaching contexts as it focuses on the interaction between internal and external factors (Bruning, Scraw, & Ronning, 1999). This is supported by Vygotsky’s theory which emphasizes integration of "internal" and "external" aspects of learning (Vygotsky, 1978). According to the Vygotsky's theory, an individual’s interactions in a social and cultural context form the basis of all higher human cognitive functions.

Social constructivist theories on child development, learning, language acquisition and development and cognition continue to influence teaching of science. Teachers should note that learning is an interactive process through experiences with different aspects in one's environment such as peers, parents, teachers, and resources. Working with others allows mechanisms of social construction of knowledge (Crotty, 1998) as teachers look for their understanding of what they learn from their immediate environment. Teachers, like their students, construct meaning from their experiences and also make personal meaning of their new experiences by fitting the new information into their existing frameworks (Lemke, 2001).

Teachers’ cultural backgrounds and daily language at home affect the way they conduct classes during school science discourse. Continuous educational research on school science teaching and learning, based on constructivists theories (Schunk, 2000), is required to inform construction and development of scientific knowledge by students in different contexts. Teachers' personal frameworks influence how they use a science-technology-society approach in teaching (Bouillion & Gomez, 2001). Diversity in science classrooms requires special science teaching and learning interventions. Continuous focus on teaching school science from a western perspective disadvantages many students from different socio-cultural backgrounds. By incorporating multicultural education in science (Atwater, Radzik-Marsh, & Strutchens, 1994), teachers will be able to assist their diverse students to have smooth "border-crossings" (Aikenhead, 1998) into school science micro-culture and make sense of the "companion meanings" generated during classroom discourses (Roberts, 1998). Kenya has 42 different indigenous African languages spoken in the rural areas where the majority of school going children live and attend school. In these rural areas, English is the medium of instruction starting from grade four. Teaching science from a western perspective and in English as a second language is likely to leave students with many "borders" to cross. The classroom science discourse is likely to have many "companion meanings" to the rural school students in Kenya.

Social constructions of knowledge continue to take place whenever one interacts with his or her environment. It has been argued that instruction must be designed in such a way to provide experiences that effectively interact with students' prior knowledge in order for them to construct their own understanding" (NSSE, 2000, p. 31). Teachers should know that learners' science knowledge is not acquired but made through construction of their own sets of meanings or understandings through social interactions.

The context in which teachers live and work influences their perception about teaching and learning. As members of society, teachers value and practice their communities' culture. The teachers' culture influence the way they view their teaching and learning of school science. The interactions experienced by teachers in and outside school may influence their change in beliefs about teaching, learning or professional development in science education.

Teacher Beliefs and Practical Knowledge About Teaching and Learning

Constructions of knowledge through social interactions within given contexts are closely linked with an individual's beliefs about various forms of knowledge and practices. Although there is no one common definition about beliefs, beliefs have been defined as "psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p. 103). Beliefs are cognitive and not measurable nor observable but can only be inferred from teachers' thought processes and actions (Clark & Peterson, 1986).

Effective science teaching and learning environments are greatly influenced by a teacher's mastery of pedagogical content knowledge (Chiapetta & Koballa, 2002). Knowing how to effectively implement a given curriculum to a group of learners, in a given context, maybe considered as a teacher's practical knowledge about teaching and learning. One's practical knowledge about teaching occurs through personal experiences, experiences with schooling and instruction, or formal experiences in one's education career (Richardson, 1996). Personal experiences within a given context contribute towards an individual's view of what teaching entails. One's metaphor for teaching may therefore reflect what he/she experienced from his/her local environment. For instance, a student born and brought up in a family that values parenting is likely to see teaching as nurturing. One becomes more knowledgeable about teaching through participation in various education programs, as students themselves, and observations of experienced teachers handling lessons in classes (Bryan, 2003).

Richardson (1996) defined formal knowledge as "understandings that have been agreed on within a community of scholars as worthwhile and valid" (p. 106). In school, one is exposed to subject content matter and develops knowledge about the nature of subject matter and how to learn it. Pre-service teacher education programs provide students with first-hand experiences on pedagogical knowledge. However, many teacher education programs offer few opportunities that will help teachers develop connected conceptual understandings of subject content matters that they are expected to teach. Richardson noted that many studies done on teacher education show that pre-service students and in-service teachers' beliefs are strongly affected by a combination of personal and schooling experiences.

A teacher's practical knowledge about teaching grows with one's experience in teaching. This practical knowledge is tacit, integrated, action-oriented, person and context bound, and belief based (vanDriel, Beijaard, & Verloop, 2001). Teaching experiences influence one's beliefs about teaching. It has been argued that "beliefs are thought to drive actions while experiences and reflection on action may lead to changes in and/or additions to beliefs" (Richardson, 1996, p. 104). Richardson (1996) argued further that research attention to both beliefs and actions through interviews and observations enhance an understanding of a teacher's practices. Changes in teacher beliefs and practices are likely to be enhanced through collaborative efforts during professional development programs (Barufaldi & Reinhartz, 2001; Sapovitz & Turner, 2000).

Richardson (1996) argued that practicing teachers' perception about teaching, learning, and subject content matter influence their participation in professional development programs. Bryan (2003) noted that "understanding how teachers learn is a daunting undertaking because it requires understanding of not only their perceptions, but also the relationship between their beliefs and actions" (p. 862). This assertion concurs with Clark and Peterson's (1986) model of teacher thought and action. In this model, teachers' thought processes encompass teacher planning, teachers' theories and beliefs, and teachers' interactive thoughts and decisions.

Teachers make choices and decisions on what they are to teach and how they are to teach the selected content in their science classes. In this regard, lesson planning and preparation becomes an important component in science teaching and learning (Danielson, 1996).

Lesson Planning

Planning is seen in two ways: "as a set of basic psychological processes in which a person visualizes the future, inventories means and ends, and constructs a framework to guide his/her future action" or as "the things that a teacher does when he/she says that he/she is planning" (Clark & Peterson, 1986, p.260). Planning and interactive decision making are cognitive processes taking place in teachers when preparing instructional materials and implementing school curricular. Clark and Peterson (1986) saw teacher planning as including the "thought processes that teachers engage in prior to classroom interaction, and the thought processes or reflections that teachers engage in after classroom interaction that then guide their thinking and projections for future classroom interaction" (p.258).

Eight different types of planning, which are not independent but are nested and interact with one another, have been identified as the daily, weekly, short range, long range, term, yearly, unit, and lesson planning. Unit and lesson planning describe a "unit content for which teachers planned" (Clark & Peterson, p. 260). Teachers devote most of their time and energy to structure, organize for, and manage instructional time in class. The knowledge that teachers have does influence the way they plan, think and make decisions on teaching and learning activities (Bryan, 2003). However, it has been argued that despite the fact that lesson planning in particular is addressed in all teacher preparation programs, it is "rarely claimed as an important part of the repertoire of experienced teachers" (Clark & Peterson, 1986, p. 262). In traditional supervision, a teacher is usually assessed in terms of what he/she planned to teach and what actually has been taught, and his/her mastery of the curriculum content taught in class. On the other hand, recent works in education have come up with new frameworks for teaching that guide teachers in planning, implementing and assessing instructional activities (Danielson, 1996). Researchers and teacher educators have also been challenged to think more broadly on what teachers accomplish during planning time instead of only assessing the quality of planning through comparison of what was planned with what was taught (Clark & Peterson, 1986).

The linear planning model, in which a teacher specifies objectives, selects learning activities, organizes learning activities, and specifies evaluation processes, has been in use for many years but does not describe the planning behavior of experienced teachers. Recent literature on teacher education indicates that teacher planning involves other activities such as meeting administrative accountability requirements, and communicating with substitute teachers and parents (Danielson, 1996). Planning should, therefore, have teachers forming mental images that are activated from memory as a plan for conducting interactive teaching (Clark and Peterson, 1986). Clark and Peterson (1986) further observed that in order to understand teacher planning, researchers "must look beyond the empty classroom and study the ways in which plans shape teacher and student behavior and are communicated, changed, reconstructed, or abandoned in the interactive teaching environment" (p. 268).

Another area of importance in teacher education is teacher actions. Teachers' actions and their observable effects include teachers' classroom behavior, students' classroom behavior, and student achievement. The actions exhibited by teachers are in themselves a reflection of the thought processes taking place in them. These thought processes are likely to be influenced by one's beliefs which will in turn influence the decisions a teacher makes while planning, teaching, or assessing science education lessons (Bryan, 2003). As teachers develop their professional knowledge (Bryan & Abell, 1999) and continue to enhance their teaching practices through professional development programs in science education reform (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Radford, 1998), they are always confronted with a complex interaction between knowledge and beliefs in making decisions about curriculum implementation (Bryan & Abell, 1999).

Evidence from various studies indicates that in-service programs appear to be more successful in changing teacher beliefs about teaching and learning than pre-service programs (Richardson, 1996). Changes in teacher beliefs and practices are influenced by the "context and teachers' existing beliefs and knowledge" (p. 112). Richardson argued, further, that staff development programs that concentrate on teacher beliefs are important in changing instructional practices while constructivist approach-based programs are "successful in engaging participants in examining and changing their beliefs and practices" (p. 113). Richardson further stated that for successful constructivist staff development programs, the "goal of the process is to facilitate conversations that allow the participants to understand their own beliefs and practices, consider alternatives, and experiment with new beliefs and practices. The teacher should be given control of the agenda, process, and content during discussions among staff developers and teachers; and the staff developer should not be seen as the only 'expert' but provide opportunities for the teachers to recognize and value their own expertise" (p. 113).

According to Richardson (1996), experienced teachers' deep practical knowledge is closely linked to their actions. These actions are influenced by their beliefs about teaching and learning. Focus on teachers' action is likely to assist in understanding how changes in teacher beliefs and practices affect student learning. Richardson noted that there was "need to move beyond descriptions of pre-service and in-service teachers' beliefs and conceptions and towards the observation of teachers' actions in the classroom and their students' developing understandings" (p. 114).

Teachers are the most important change agents at the classroom level and the ultimate implementers of any curriculum reform. It is known from previous research that educational innovations usually do not succeed if teachers are not provided with the skills and knowledge needed to carry them out (Pelgrum, 2001). Teacher preparation and development is a very expensive activity and hence, often much neglected in large-scale innovations. I have interest in examining teachers' expectations, practices, and experiences about chemistry unit lesson planning following their staff development and support services' courses in Kenya. What is perhaps even more important in the early stages of adopting innovations is the role played by leadership 'gatekeepers' such as school principals. From the in-serviced teachers' perspectives, to what extent is the school management offering a supportive climate for in-serviced teachers to incorporate new approaches/strategies in teaching secondary school chemistry?

As teachers, we need to be systematic and reflective about our teaching practices (Bryan, 2003). Our beliefs about teaching and learning are largely tacit. We operate a good deal of the time from an intuitive sense of what our intentions might be and what our actions could be saying to students. Our beliefs about learning and teaching can only be uncovered by engaging in systematic self-critical analysis of our current instructional practices. In addition to active reflection, theory and reading other colleagues' work about pertinent topics are important as well. Discussion with others is a very valuable aspect of action-oriented educational research (Gianotti, 1994). It is important to note that theory must inform practice, and practice informs theory.

Planning for practical sessions in science classes needs thorough thoughts about the words to be used in the instructional materials. For instance, teachers' continuous use of the following terms in laboratory instructional sheets for students do lead to misconceptions on the actual quantities required: "add some" and "add a little"; "add a few drops of…or warm...for a few minutes"; "weigh about…grams of…” and "add the alkali in excess." In another example, understanding of abstract science concepts such as current and energy (Wesi, 2003) can also be tricky to teachers when teaching the electrochemistry topic in schools. Chemistry teachers' laboratory instructions that require students to observe color changes or smell gases produced in a reaction, or note the (e.g. hissing, "pop" or cracking) sounds produced by reacting chemicals during qualitative analysis of substances is a challenge to color-blind, non-smelling, and hearing-impaired students, respectively, in public schools. Through appropriate in-service activities, inexperienced teachers can be assisted to avoid such words that are likely to cause confusion among the students during class experiments.

It has been argued, further, that many teachers tend to teach using the "traditional methods" they were exposed to as students, both in class and during their teacher education courses and practice teaching. Teachers with such experiences are likely to have difficulties in understanding and teaching inquiry-based science concepts (Keys & Bryan, 2001) or handling multicultural issues in science education (Atwater, Radzik-Marsh, & Strutchens, 1994). Teachers constructively, however, enhance their teaching by employing appropriate and relevant teaching strategies and methods in science education (Chiapetta & Koballa, 2002).

Improved classroom practices are realized with teachers’ experiences and appropriate pre-service teacher education programs (Cochran, DeRuiter, & King, 1993) supported by well designed professional development programs (Loucks-Horsley, Hewson, Love, & Stiles, 1998;

Radford, 1998; Sapovitz & Turner, 2000; Sweeney, Bula, & Cornett, 2001; vanDriel, Beijaard, & Verloop, 2001). This ought to involve, among others, teacher interactions, reflections, and mentoring (Bryan, 2003; Chiapetta, & Koballa, 2002).

Professional Development

Little (1990) argued that teamwork helps teachers to reflect on their use of ineffective teaching routines, and how to develop and examine new conceptions of teaching and learning. In team-teaching, teachers share ideas on how to plan and prepare lessons, and observe each other's classroom teaching as they learn from each other by being educated together and also educating one another (Little, 1990). Professional development of teachers is important because it offers teachers a chance to reflect on science education reforms in relation to appropriate curriculum changes and also changes in teachers' beliefs of subject matter and practice (Palincsar, Magnusson, Morano, Ford, & Brown, 1998; McLaughlin & Talbert, 1993; vanDriel, Beijaard, & Verloop, 2001). Teachers are also likely to learn more from each other and change their perceptions as they interact/socialize within school environment during professional development (Putman & Borko, 2000).

Teachers who have undergone educational experience following constructivist approaches are likely to accommodate their students' personal frameworks (Driver, 1995) and indigenous science knowledge (Thomson, 2003; Thomson & Chepyator-Thomson, 2002) during science classroom discourses and investigations. This view is supported, partly, by the argument by Driver (1983, p. 24) that "students possess conceptions of natural phenomena that may differ drastically from those held by scientists. Their variations occur with respect to common everyday phenomena; and students try to interpret unfamiliar concepts using analogies with familiar experiences." In this context, teachers ought to change from teaching science using traditional methods and incorporate recent developments in science teaching. The impact of such changes in science teaching maybe determined through studies of teachers' experiences, beliefs and classroom practices in schools following professional development programs (Loucks-Horsey, Hewson, Love, & Stiles, 1998; Radford, 1998; Sapovitz & Turner, 2000; vanDriel, Beijaard, & Verloop, 2001). Against this background, an interpretive research design in science education (Gallagher, 1991) was required to investigate the in-serviced chemistry teachers' classroom practices and experiences in designing and implementing ASEI chemistry unit lessons employing the PDSI approach in Kenya.

Professional Teacher Development Models

There are many professional development models for teachers (Lavoie & Roth, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998). Professional development models are important in guiding the planning, organization, implementation, and monitoring and evaluation of any teacher education program or project. Various frameworks of professional development models in teacher education maybe used to evaluate the impact, effectiveness, relevance, efficiency and sustainability of the SMASSE in-service project in Kenya. Although a cascade system of in-servicing teachers was employed, it can be argued that the SMASSE project appeared to incorporate many aspects found in other models such as the collaborative, staff development, teacher as a curriculum developer, and "instructional congruence" models. In this section, only these four in-service education models are considered relevant to this study on the SMASSE Project.

Collaborative model. The collaboratives in professional development of teachers are partnerships that bring together such as local education agencies, teacher preparation institutions, funding agencies, school districts, business and industry, informal education sites, such as the state aquarium and museums. The partnerships work together through cost-sharing and in-kind contributions to support science education reform throughout a given region. The instructional teams at regional sites maybe made up of professors from local universities, community college instructors, science supervisors and coordinators, and master teachers from local high schools (Barufaldi & Reinhartz, 2001). The main goal of the collaboratives is to provide public school teachers' opportunities to upgrade their content and pedagogical knowledge to enable them offer their students interesting, relevant, experiential, and meaningful science learning experiences (Barufaldi & Reinhartz, 2001). To achieve this goal and also meet the needs of underrepresented and underserved groups in science, a strong focus has been placed on aligning professional development with the local needs of education.

The traditional methods of in-servicing teachers using experts who tell teachers what to do in schools to enhance science teaching and learning has been criticized by many scholars in professional development of teachers (Barufaldi & Reinhartz, 2001). Traditionally in-servicing of teachers was based on a deficit-model. The teachers were viewed as if they were lacking some content knowledge or skills to enable them teach school science better. Teachers were treated as mere recipients of the in-service programs with hardly any input during the planning, implementation and evaluation stages of the professional development programs. The in-servicing of teachers was, therefore, seen as an external work conducted by experts. The experts prepared the in-service curriculum and materials, educated and supervised teachers according to their criteria of equipping teachers with skills/knowledge lacked in content/pedagogy areas.

Professional development programs should treat teachers as participants and decision-makers of their education activities. This professional development model can be classified as competency-based because it assumes that teachers "want to learn and are constructors of new knowledge in an environment that is collaborative and safe for experimentation, and are able translators of these experiences into developmentally appropriate curriculum materials." (Barufaldi & Reinhartz, 2001, p. 90). According to Barufaldi and Reinhartz, constructivist and sociocultural theories support these assumptions and perceptions on teachers/teaching in relation to professional development of science teachers. Through collaborative efforts, teachers make reflections on their teaching experiences and what they learn during their professional development sessions. They have opportunities to exchange their views with colleagues and are able to make sense of any scientific misunderstandings or misconceptions that may arise during their professional development. Teachers are able to generate their own solutions to problems they encounter in their respective schools. This is important because each school has its own unique problems requiring unique solutions applicable to it. The traditional in-service teacher education models give teachers the same recipe for all schools and students regardless of the prevailing local environments. The collaborative model offers teachers opportunities to be together and share visions through interactions.

Need for changes on the way teachers are in-serviced, for example in the United States of America, has been necessitated by systemic school reform efforts (Barufaldi & Reinhartz, 2001) which "call for a new way of thinking about change and innovative strategies to initiate such change." (p. 92). It is assumed that more can be achieved through active collaboration among stakeholders in professional development of science teachers. Collaboration in professional development of science teachers has to "be learned, practiced, nurtured, and supported." (p. 92). It is worthwhile to have teachers undergo professional development in the methods they are expected to apply when teaching school science.

One way that teachers may succeed in having their students achieve in science is through collaboration with other stakeholders in the school system. Professional development efforts ought to inform teachers about the importance of having well-coordinated school organizational structures for proper functioning of the whole school system to benefit students' learning science. This requires "clear understanding of the interconnectivity among and between individuals within the organizational units for the system to function productively." (Barufaldi & Reinhartz, 2001, p. 94). When teachers are offered opportunities to develop themselves professionally through collaboration, they are likely to be have a sense of ownership and commitment to the education programs aiming to enhance teaching and learning in schools.

The collaborative teacher professional development program model has many benefits to the stakeholders: schools, teachers, universities, public and business communities. Through collaborative efforts schools end up having better prepared science teachers that lead to increased student enrollment in science. Schools, having highly motivated and professionally educated science teachers, provide good learning environments to all students using different teaching strategies and technology networks.

The collaboratives lead to unprecedented collaboration within and across regions in support of high standards for all students (Barufaldi & Reinhartz, 2001). Through collaboratives, teachers are empowered to teach and assess school science more effectively. Collaboration environments during professional development activities are likely to increase teachers self esteem in terms of new leadership roles and expanded content and pedagogical knowledge in science. The universities are able to work with other stakeholders in sharing their resources (professor expertise, facilities, and materials) and having committed focus on systemic reforms (Barufaldi & Reinhartz, 2001). The collaboratives link the universities with society to which their graduates are to enter. These links are likely to have meaningful teaching at universities leading to increased graduate enrollments as university credits are considered in staff development units. The local communities benefit from the collaborative efforts because the universities are able to prepare teachers based on local, state and federal standards, and there are improved student achievements in schools as a result of teachers' enhanced teaching skills/strategies (Barufaldi & Reinhartz, 2001).

On the other hand, the collaborative professional development model only looks at how to enhance science teaching through collaboration but does not consider other issues that affect individual teaching or learning. The model relies on constructivist and sociocultural theories as a way of empowering teachers with relevant teaching strategies and skills, while many teachers and students have other problems that need other interventions. Effective professional development of teachers ought to consider gender and equity issues in science teaching. Along with collaboration in teacher development, multicultural science education ought to be emphasized in teacher education (Atwater, Radzik-Marsh, & Strutchens, 1994). Unless teachers understand the needs and culture of students from low social economic areas, collaboration efforts will only be successful in areas with students from privileged families. Professional development of science teachers maybe strengthened if it is issue-driven and aiming at having all students achieve same goals in education.

The staff development model. Professional development programs that involve the staff development initiative models are organized by individual schools, a group of schools or the local district education agency with an aim of developing permanent structure systems that continuously support the implementation of desired teaching/learning activities (Loucks-Horsley, Hewson, Love, & Stiles, 1998). An example of a staff development model is that of Cambridge

City, Massachusetts implemented in the 1990s focusing on a common inquiry-based elementary science curriculum (Loucks-Horsley, Hewson, Love, & Stiles, 1998). The Cambridge City staff development initiatives model assumed that through a three-tiered approach (with five staff development teachers, two liaison teachers with full teaching responsibilities, and all elementary school teachers in Cambridge city) in teacher enhancement program, teachers would increase students' achievement in science through implementation of hands-on and inquiry-based elementary science curriculum.

According to Loucks-Horsley, Hewson, Love, and Stiles (1998), the staff development program was designed assuming that strong support from the stakeholders (education officials, schools, classroom teachers, and school community) plays an important role in having successful districtwide systemic reform of science education. It was also assumed that a centralized curriculum reduces chances of having misunderstandings between education officials and the classroom teachers; and professional development programs ought to consider diversity among stakeholders (e.g. different levels of tiers, interest, and expertise of teachers). In this model, the teachers undergo a long process of transformation before they can successful implement inquiry-based science curriculum activities in their classroom. Another assumption is that sustainability of science education reforms depends on capacity building within and in all levels of the system.

The staff development teachers for the professional program in the Loucks-Horsley, Hewson, Love, and Stiles' (1998) study were practicing teachers who were selected based on their experience and interest in teaching science and playing a role in supporting other teachers. These teachers undertook professional development programs on curriculum development, design, and implementation, and developed skills in inquiry-based teaching, workshop leadership, institutes, and presentation. They learned various professional strategies, among them, how and why they should plan for weekly meeting. They underwent ten professional working days to learn more on inquiry-based teaching, mentoring, peer support, and group leadership. They learned from other experts through apprenticeships and mentoring. They also learned on how to make teachers under their jurisdiction access individual professional development growth (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Liaison teachers were school-based teachers, with special skills and interest, who worked with the five staff development teachers to support the schoolwide implementation reform. The two liaison teachers in each school were expected to keep their science classes, as a model of the science education reform in their district wanted to have in schools. They were full time classroom teachers but were given stipend and professional development time. They underwent a four-day institute in summer lead by staff development teachers and external consultants on inquiry-based activities; and participated in two types of unit workshops conducted by staff development teachers (after school meetings, and mentoring and coaching). There were also apprenticeships with workshop leaders and study groups of six to ten liaison teachers pursuing issues that interested them (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Regular classroom teachers were a cadre of teachers who underwent in-servicing following a two-day summer institute developed for each unit developed by the district, and were also given individual support by staff development teachers who were available in each school at least once a week. The idea of having teachers helping each other to develop professionally is wonderful. A professional development program that recognizes and offers teachers opportunities to explore their talents and share their experience with their fellow teachers in schools is worth many successes compared to an in-service program where experts tell teachers what they ought to do during their science teaching. Mentoring and coaching of teachers are important aspects in professional development as teachers have opportunities to share experiences on cases of real world teaching dilemmas. Teachers' involvement in curriculum development and making decisions on curriculum implementation helps them to adapt the science education reforms and to claim ownership of the reforms.

On the other hand, the model does not consider issues of multicultural science education. Many children likely to experience poor foundations of elementary science are those from low social economic areas. Although these groups of children are as intelligent as any other human being, they are usually labeled as special needs children and placed in lower tracks in school. Unless science is made relevant to children's practical experiences, inquiry-based curriculum and hands-on activities in science classes will continue to marginalize many children regardless of the professional development programs available to teachers. The staff development programs should also involve the principals so that they are able to provide teachers with release time and also appreciate their roles in the provision of adequate teaching/learning materials in science in schools.

Teacher as a curriculum developer professional program model. Professional development programs that involve teacher as a curriculum developer model enable teachers to actively carry out education reforms through participation in curriculum materials' development and implementation of a new course of integrated studies (Loucks-Horsley, Hewson, Love, & Stiles, 1998). In such professional development programs, teachers learn how to develop, implement and disseminate new instructional materials. For example, professional development programs that integrate science concepts and meet the criteria of education reforms had to be developed in the United States during summer workshops or institutes or meetings. Global change was found to be a popular subject because of its relevance to students' everyday life experiences and wide application of inquiry-based learning activities. Collaborative efforts in developing instructional materials in professional development programs appeal to many audiences. The curriculum materials developed in these circumstances are appreciated by many teachers and implemented with ease unlike materials developed through individual efforts (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Individually developed materials are likely to take long in reaching other teachers in schools and might take time to be appreciated by other teachers. Individually developed curriculum materials are also likely to consume considerable amounts of time as other teachers repeat making them.

During the professional development sessions, teachers are provided opportunities to share their insights on content and process of teaching the curriculum materials they pilot in their own classrooms (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Based on their reflections, the teachers develop new activities and assessment tasks for the new course or program depending on scheduled times. For instance, during the summer institutes sessions in the United States, teachers have opportunities to visit research scientists in their laboratories. This helps teachers to see the relevance of the curriculum materials they develop to real life outside school (Loucks-Horsley, Hewson, Love, & Stiles, 1998). In this context, teachers are able to relate the new curriculum concepts and provide students with excellent explanations because the teachers have developed the materials themselves and have been exposed to the research scientist in which they observe them work in their laboratories.

Using the teacher's guide, students' understanding of a given taught unit is assessed. Guidelines as to how the teacher should keep his or her portfolios of student work are also provided in the teachers' guide (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Collaboration efforts between experts and classroom teachers in the development of curriculum materials are a great idea in professional development of science teachers.

Teachers have opportunities to interact with other teachers as they develop innovative activities and teaching approaches for the new courses (Loucks-Horsley, Hewson, Love, & Stiles, 1998). This is an important aspect in professional development as communities of teachers, with common interests, are able to interact and share ideas that promote teaching/ learning activities in schools. Teachers are able to use conferences, electronic bulletins, and newsletters to enhance their teaching skills/approaches. Involving teachers in curriculum development helps them to grow professionally and enjoy teaching the curriculum they participated in making. Experienced teachers are recognized and play a big role in developing realistic curriculum and instructional materials that are application to given school or district settings.

The collaborative effort in developing the instructional materials helps teachers to pool their intellectual resources and experiences together and come up with a popular product for all schools. Teachers' reflections and assessment of their students understanding of the new course and determining the kind of instructional materials to be developed is an important aspect in professional development programs. This makes the teachers effective in their curriculum implementation strategies since they understand the whole curriculum development process.

"Instructional Congruence" professional development model. An example of an "instructional congruence" professional development model was implemented (as a research) from 1995/96 to 1997/1998 academic year in a metropolitan school district in the Southeast of the United States, which had a high proportion of students from non-English language speaking backgrounds. The district had 51% Hispanic, 34% Black, 13% White non-Hispanic, and 2%

Asian and Native American students. Thirty percent of these students were enrolled in English to speakers of other language programs (Lee & Fradd, 2001).

The use of "instructional congruence" professional development model is to "enable linguistically diverse students to achieve high academic standards in science and literacy." (Lee & Fradd, 2001, p. 109). The instructional congruence model takes into consideration the cultural backgrounds and language of students in science classes. This ensures that students are provided with opportunities to make sense of the school science concepts learned in relation to their cultural contexts and language they understand and communicate well in.

It has been argued that many students in public school systems come from diverse backgrounds while there is no clear provision as to how equity, for example in science education, can be achieved by all students during the school curriculum implementation (Lee & Fradd, 2001). Appropriate science teaching and learning strategies ought to be employed to assist these groups of students if they are to benefit from the public school systems. One might ask the question: How can teachers achieve this goal? "A comprehensive set of teaching practices is required to promote achievement in science content areas while simultaneously developing literacy and English language proficiency." (Lee & Fradd, 2001, p. 110).

From a constructivist perspective (Driver, 1995), students from different cultural and language backgrounds are able to explain various scientific phenomena based on their practical experiences and languages. One can imagine the learning dilemmas students with English as their second language face in class when learning science (Rollnick, 1998) from a teacher who has no regards for their cultural backgrounds. Students from diverse backgrounds ought to be helped to cross the border crossings (Aikenhead, 1998) during science education classes by teachers prepared on how to handle students from diverse cultures. Contextualized and sociocultural perspective in science teaching (Lemke, 2001; Rodriquez, 1998) can enhance students' learning and achievement of the desired goals in science education. Lee and Fradd (2001) argued that teachers who share the same language and culture as their students are able to make the students to participate more effectively in learning school science.

The four components of the instructional congruence model in science education include students, teachers, science, and literacy. Teachers integrate knowledge of the students' language and cultural experiences, science learning, and literacy development when handling students from cultural diverse backgrounds (Lee & Fradd, 2001). The model provides "subject specific" pedagogies compatible to students from different cultural backgrounds. In this professional development model, there is congruence with both academic content and the students' language and culture. There is also promotion of student learning science and literacy in this model. At the "core of the instructional congruence model in professional development is constructivism." (p. 112). Through constructivist teaching approaches, students are made to appreciate their languages and culture in addition to increased academic achievement in science and literacy.

The model is based on strong theoretical frameworks that support the teaching of school science from different perspectives that inform science education and literacy. Incorporation of multicultural science education issues makes the instructional congruence model an excellent intervention measure to address the problems of border crossings students from diverse cultural and language backgrounds experience when learning school science. The model is strengthened, further, by having constructivism as the core of instructional congruence in science and literacy. Students benefit directly from an instruction that incorporates their cultural and language backgrounds (Rodriquez, 1998) because the teacher is able to cater for the students needs/differences in school. The teacher and the student are able to appreciate each other.

The instructional congruence model, however, fails to address the problem of inequity and inaccessibility of education opportunities to students from low social economic communities. While the model is quite insightful, there is need to have science textbooks written in the students' first languages and development of curriculum materials that incorporate instructional congruence strategies. The model ought to be introduced into pre-service teacher education because many teachers graduate from colleges having not been adequately exposed to the schools they go to teach which are, in many cases, different from their cultural backgrounds.

CHAPTER 3

EDUCATION IN KENYA

Education in the Kenya Colony

Kenya became a British Colony in 1920, after being run as an East African Protectorate by British East Africa Company for several years. During the colonial period, Kenya had a racially segregated education system - for Whites, for Asians and for Africans. The Whites' science education curriculum was superior compared to that of the Asians. The science education curriculum for the Africans only prepared them to become farm attendants and not for any office work. Mission schools, run by different denominations, offered religious education, carpentry, and agriculture to African students.

Education in Independent Kenya (1963 -2004)

After independence in 1963, Kenya started to address its educational needs through a number of Education Commissions and Committees. Through the Ominde Report (1964), Kenya abolished the racially segregated education system and replaced it with one education system for all Kenyans regardless of color, race, ethnic group, religion or gender. The 1964 Education Commission also addressed human resource shortage that Kenya faced at independence. Another Education Commission (Koech Report, 1999) and Presidential working parties (Mackay Report, 1981, Kamunge Report, 1988) or committees (Gachathi Report, 1976) on education were also set up to address Kenya's various educational needs including expansion of educational institutions.

By the year 2002, Kenya had 3028 public secondary and over 17000 primary schools (SMASSE Project, 1998). Today, District Education Boards (DEBs) and school committees together with Parents' Associations manage primary schools (Eshiwani, 1993) whereas the Board of Governors (BOG) and Parents Teacher Associations (PTAs) manage secondary and tertiary institutions. The rapid education expansion in Kenya has seen the education system changed from that inherited at independence (Sifuna, 1990) to 7-4-2-3 and then to the current 8-4-4 education system.

The rationale of restructuring Kenya's education system under the 8-4-4 education and “training" system (Mackay Report, 1981) was to make pre-service and in-service teacher education system more practical oriented in order to improve the quality of education at all levels; respond to the challenges of national development and the needs of the country; offer a wide range of employment opportunities through a practical oriented curriculum; ensure that the students graduating at every level have some scientific and practical knowledge that can be utilized for self or salaried employment, and further education; lay emphasis on continuous assessment as an integral part of evaluating students' abilities and achievements unlike in the past where assessment was done using a single examination at the end of the course; and offer opportunities for further education in both educational and technical areas. In broad terms, the primary science curriculum in Kenya aims at providing pupils with adequate intellectual and practical skills useful for living in both urban and rural areas, while the secondary school education aims at making the learner, among other things, to develop mentally, socially, morally and spiritually. It was also to the learner make positive contribution to the development of society; and to build a firm foundation for further education.

The expansion in education has seen Kenya move from one constituent university college to 6 public and more than 14 private universities that offer diversified fields of study. There are also several middle level (post-secondary education) colleges and polytechnics that offer diploma or certificate courses in areas such as education, agriculture, health, engineering, accountancy, and tourism (Kenyaweb, n. d). The government pays the salaries and allowances of teachers in public schools and educators in institutions of higher learning, while parents meet the cost of running the schools within their communities or where their children go to school. The selection of students wishing to join public universities is done through the Joint Admission Board (JAB). Public university students' tuition and living expenses are paid either by the government through schemes such as the bursary scheme or through the Higher Education Loans Board (HELB), which grants loans to the students.

In the area of science education, Kenya's rapid education expansion required more educated science teachers and science graduates to meet the demands of Kenya's labor market and economy. The government responded by making science subjects compulsory at all primary and secondary school level under the 8-4 -4 education system (Mackay Report, 1981). The government also decided to manage all public schools in Kenya and adopted the role of recruiting qualified teachers for these schools. Unfortunately, many rural schools had, and still have, inadequate science facilities because of disparities in socio-economic status of school communities and parents of the students who attend rural schools. The disparities in the provision of facilities affect the performance of the students from these areas in the national examinations that are centrally set and marked (Caillods, Gottelmann-Duret, & Lewin, 1997; The Kenya National Examinations Council, 2000). Yet examination results are used in the selection of candidates to join either secondary schools or public universities and other institutions of higher learning.

The Kenya Government also uses the quota system to admit students into institutions of higher learning and teacher education institutions, but in educational fields such as engineering, medicine, dentistry and pharmacy, the quota system cannot be used. This obviously disadvantages students from marginalized areas of the country. Marginalized areas include semi-arid areas affected by perennial droughts and poor infrastructure. Students from such areas are often unable to compete favorably with their counterparts from other agriculturally well endowed regions of Kenya.

Another barrier results from the language of instruction in Kenyan educational institutions, which is English starting from grade four. Many students, especially those in marginalized areas and those who predominantly speak indigenous languages, often strain to learn various concepts in science as a result of language barriers (Bunyi, 1999; Akinnaso, 1990; Cleghorn, Merrit, & Abagi, 1989; Rollnick, 1998). The national curriculum and examinations ensure that all Kenyan children have access to the same curriculum. However, this does not allow learning of scientific concepts based on the students' indigenous knowledge and languages (Thomson, 2003; Thomson & Jepkorir, 2002). Many students thus fail their national examinations not because they do not know any science, but simply because concepts in the curriculum and from which they are examined are often divorced from their immediate environments and experiential knowledge. One can only speculate about their performance were the curriculum culturally more responsive and students examined in their indigenous languages. There is need for science education in developing countries to consider and infuse socio-cultural science knowledge and values if education is to be relevant to the communities where the majority of the people go to school and work after school. A diversified and indigenized African education system (Sifuna, 1990; Lauglo, & Narman, 1987; Sifuna, 2001) might be a viable solution to Kenya.

In response to the ever-increasing population and emergence of new societal needs, the Kenya Government proposed to make some changes in its education system in 2003. New syllabi, aimed at a unified national system of instructional materials' provision for Kenyan schools, were to be implemented in phases. A new method of book distribution as from the year 2002 was one such change. It was anticipated that the first phase of the new curriculum was to start [and actually did start] in the year 2003. The first national examinations following the changes were to be in 2006. The table below gives a summary of the minimum number of examinable subjects that were to be examined in the year 2006.

Table 2

Number of Subjects to be Used in Grading Candidates

Examinable subjects		
	At present	Future (starting from 2006)
Primary	7	5
Secondary	8	7

Source: Ministry of Education, Science & Technology, Republic of Kenya (2004)

The reduction of the number of examinable subjects was meant to provide learners and teachers with adequate time to cover the broad practical-oriented 8-4-4 curriculum and prepare for the national examinations.

Science Teacher Preparation in Kenya before Independence in 1963

The preparation of teachers for African schools was initially done by missionaries and later by Africans in independent teacher education colleges (Sifuna, 1990). The colonial government also prepared teachers for White, Asian or African government schools. At that time, the science teacher education curricula were, therefore, different and only served the group providing it.

By the 1930's, the colonial government had started a few African government secondary schools to cater for the sons of the colonial chiefs and their subjects. The British also started the University of East Africa at Makerere in Uganda to absorb students from mission schools and the African government schools in the East African region. It is through the University of East Africa, Makerere, in the 1950s and early 1960s that Kenya started to receive a few Kenyan professional secondary school science teachers graduating with, at least, a diploma.

Science Teachers in Kenya at and after Independence in 1963

At independence, many expatriate White teachers opted to leave the country for one reason or another. The socio-economic and political developments at independence in Kenya also saw many African teachers, despite their inadequate qualifications, leave the teaching profession and join the government or politics. Needless to add, there was a serious shortage of teachers for the then 151 secondary and about 6000 primary schools (Eshiwani, 1993). The new government also faced another problem: Lack of teacher preparation colleges for high school teachers. There were many primary teacher-preparation institutions that were run by different groups, but their curricula, at that time, was questionable.

Faced with a shortage of science teachers in high schools as well as teachers in other subjects, the Kenya Government's most immediate intervention measures were to hire White expatriate teachers willing to serve in Kenya. This was with the promise of better terms of service, especially in sciences, as a short-term measure to address the scarcity of personnel in education. The government also amalgamated many teacher education colleges and remained with a total of 17. The government then converted an army barrack [a Whites only barrack during the colonial period] at Kahawa Garrison into a teacher education college for secondary school teachers. The college was renamed Kenyatta College, after Kenya's first prime minister and later president of the republic of Kenya, Mr. Jomo Kenyatta.

The government entered into bilateral agreements with other countries that were ready to assist in the development of science teacher education in Kenya. One of these countries was Sweden. With financial assistance from the Swedish government, the Kenya Government built The Kenya Science Teachers' College (KSTC) in Nairobi in 1966. The College was to start preparing high school graduates for three years leading to a Secondary Teacher 1(S1) certificate qualification (Thomson, 2002). Sweden's Uppsalla University professors were seconded (posted from their university) to Kenya to run KSTC for the first ten years, a period within which Kenyans prepared to take over the running of the college. The S1 teachers were the first highly qualified high school science teachers to be prepared in independent Kenya. The demand and respect for KSTC graduates has continued to grow to date even though Kenya currently has many graduate science teachers graduating from the six public and two private universities that offer teacher education (Thomson, 2002).

The Kenya Government strengthened the teaching of science in schools through relevant education policies that focused on expansion of schools, on offering an advanced level of science education and on a higher pay for science teachers compared to their counterparts with similar academic and professional qualifications. In Kenya today, high school science teachers are prepared in the public universities (Kenyatta, Nairobi, Egerton, Moi, and Maseno) that offer teacher education and in three diploma teacher-education colleges (KSTC, Kenya Technical Teachers College, and Kagumo) that offer sciences and other technical subjects. There are also two private universities, run by religious organizations, offering education courses in Kenya.

Secondary School Science Teachers' Professional Development Programs in Kenya since 1963

Prior to July 1998, either the Ministry of Education, Science and Technology's Quality Assurance and Standards' division and the Kenya Institute of Education (a curriculum development center) or The Kenya National Examinations' Council organized one-to-three day seminars, workshops or conferences for secondary school science teachers on curriculum material development/implementation and examinations. This involved the selection of a few teachers from schools in given districts to attend such seminars or workshops or conferences, especially in Nairobi, Kenya's capital city. Unfortunately, these professional development efforts were not well-coordinated for science teachers especially on how to enhance teaching and learning of school science in Kenya. It is equally disheartening that science teacher preparation has continued to employ traditional methods of teacher preparation, something that is reflected in school science classrooms. Many teachers continue to employ didactic teaching and use of "recipe" type experimental work for students.

In more recent years, Head Teachers Associations have been involved in in-service science teacher education in their respective districts. Through these associations, schools contribute funds for science teachers' seminars aimed at enhancing teachers' instructional strategies or setting of common mock examinations for students preparing to do high-stakes national examinations at the end of any given year. The only limitation with the Head Teachers Association initiatives is that some districts are unable to conduct these seminars because of socio-economic disparities prevalent in Kenya's varied geographical regions. Another professional body, the Kenya National Union of Teachers (KNUT), is supposed to be at the forefront in promoting the professional development of the teachers in Kenya. KNUT has, however, continued to play a key role in trade union matters that focus on teachers' salaries at the expense of professional matters. Although the financial affairs of teachers are important, if not more important, efforts by KNUT need to be balanced towards an all-rounded approach towards teachers' professional and social economic welfare.

As mentioned earlier, the Kenya Government has made many educational reforms in endeavors to make education more responsive to technological advancement and labor-market needs (Mackay Report, 1981). One of the reforms, in 1984, was in the making of science subjects compulsory in all public schools in the new system of education: eight years of primary education, four years of secondary education, and a minimum of four years for a basic university degree. Many schools did not have adequate provision of science facilities to effectively implement the new national curriculum nor were there high quality in-service professional development courses for teachers on how to implement the new broad and practical-oriented curricula (Aduda, 2003; Kamau, 2002; Kinyua, 2002). Challenges in disparate educational provisions of school science facilities, resources and services can best be understood against the backdrop of the fact that all students in public schools in the country have to take the national examinations. It is thus not surprising that many candidates perform poorly in the national science examinations (Waihenya & Siringi, 2001) as well as some of the other subjects like English. The candidates' poor performance in national science examinations prompted the Kenya Government to seek intervention measures aimed at strengthening mathematics and science in secondary education through in-servicing of teachers in 1998, with assistance from the Government of Japan through Japan International Cooperation Agency, JICA, (SMASSE Project, n. d.).

Strengthening Mathematics and Science in Secondary Education (SMASSE) Project in Kenya

The purpose of the SMASSE project was to enhance young Kenyans' capability in mathematics and science through in-service teacher education based on a cascade professional development model. The SMASSE Project was started as a pilot project in July 1998 and was to end in June 2003. The outcomes of the pilot project informed the government on how to implement year-round science teacher education programs in Kenya. The Kenya Government accepted the project recommendations to implement all-year round professional development courses for science teachers starting from May 2003 (SMASSE Project, n. d.). One of the implications of government reforms is that future promotions for science teachers were to be based on teaching experience and the number of staff development units gained from in-service teacher education programs. This was a commendable step in the direction towards having uniform criteria for promoting teachers while enhancing the teaching and learning of school science in Kenya.

CHAPTER 4

RESEARCH DESIGN

Methodological Perspectives

This multi-site qualitative research case study (Stake, 1994) investigated chemistry teachers' beliefs and experiences in designing and implementing chemistry unit lesson plans following the SMASSE Project in-service teacher education courses in Kenya. This study was conducted from a constructivist perspective because I believe that teachers were likely to construct and make meaning of knowledge about teaching and learning based on their environments. Through a constructivist framework, I was able to interpret the chemistry teachers' experiences and how they changed their practices about teaching and learning following in-service programs. The research study sought to answer the questions:

1. How do the SMASSE Project in-service teachers design secondary school chemistry unit lessons in Kenya? What influenced their lesson designs?
2. How do the SMASSE Project in-service teachers implement secondary school chemistry unit lessons during instruction in Kenya? What influenced their lesson implementations?
3. What changes in practice did teachers in-serviced by the SMASSE Project make when designing and implementing secondary school chemistry unit lessons' plans in Kenya? Why did they make changes in their lesson designs and implementation?
4. What are the in-service teachers' reflections concerning their experiences with respect to strengths and weaknesses of the SMASSE professional development program?

The scope of the study involved two of the original nine SMASSE Project pilot districts purposively selected based on disparity in provision of school resources and to my convenience in terms of time and cost of conducting research in such districts.

Research Settings

The study was conducted in Kenya, which had a centralized education system administered by the Ministry of Education, Science and Technology (MOEST), and whose chief accounting officer was the Permanent Secretary. The Education Secretary, a professional, headed the education administration division, while the quality assurance and standards division, which establishes and maintains educational standards, was headed by a director. The quality assurance and educational standards division was responsible for, among others, implementing and monitoring professional teacher development programs at all levels of the education system in Kenya. The director of quality assurance and educational standards was the national SMASSE project coordinator through the educational administrative areas (Table 3)

Table 3.

Educational Administrative Areas in Kenya

Administrative and Educational areas	Total	Covered by SMASSE Project	Percentage
Provinces	8	5	62.5
Districts	71	9	12.7
Secondary schools	3028	About 410	13.5

Kenya has eight administrative (educational) provinces, each headed by a provincial director of education, with a total of 71 districts, and each headed by a district education officer (Table 3). The districts are further divided into educational divisions, each headed by an assistant education officer. In the field, the quality assurance and standards' officers work under the education officers in-charge of the various areas in which they work. In 1998, the SMASSE Project was implemented in nine pilot districts (Kisii, Gucha, Kajiado, Kakamega, Butere/Mumias, Lugari, Maragwa, Murang'a, and Makueni) that were in five provinces (Nyanza, Rift Valley, Western, Central, and Eastern). In the year 2004, there were 3,028 public secondary schools in Kenya. The Project covered 62.5 per cent of the provinces, 12.7 per cent of the districts and about 13.5 per cent of the public secondary schools in Kenya.

Kenya's public school system is made up of different school settings in which students are divided by sex/gender and are either boarders or day scholars. The public schools are also categorized into national, provincial, or district schools. The in-service chemistry teachers were practicing teachers in either provincial or district schools because the SMASSE pilot districts had no national schools. Male or female principals headed the 3,028 public secondary schools in Kenya regardless of the different settings or sex/gender.

Participant Selection

The pilot SMASSE Project to in-service chemistry teachers initially interviewed and selected four senior teachers in chemistry from each of nine pilot districts (see Figure 2) for in-servicing at the national In-service Education (INSET) Unit based at the Kenya Science Teachers College in Nairobi. Interested teachers applied to their district education boards for short-listing. Short-listing was based on teachers' teaching experience and minimum job group grade "L" and above. In Kenya, professional secondary science teachers are employed at various job groups, depending on professional qualifications, starting from Job group "G" and with experience are promoted through various grades, the highest grade being job group "R" - chief principal level. Four teachers, from each of the nine pilot districts, were selected for the national SMASSE in-service teacher preparation program. Those “trained” at the national level were to “train” their colleagues in their respective district areas at the district SMASSE INSET Units.

The study targeted in-serviced chemistry teachers in the pilot districts, the four in-serviced for each district at the national SMASSE INSET Unit, and those who were in-serviced with the Project at the pilot district level. It was assumed that each school had a chemistry teacher in-serviced by the SMASSE project, thus giving the pool of chemistry teachers in-serviced in each district to be approximately forty. Because of financial constraints as a self-sponsored researcher, the study sample involved purposive selection of any two districts from the original nine SMASSE Project pilot districts (convenient to the researcher in terms of transport and closeness of schools where the participants taught). Simba and Chui Districts were selected. Purposeful selection of participants (LeCompte & Preissle, 1993) was done to recruit high school chemistry teachers for the study. Based on the accessibility of participants' schools in the selected districts, I selected all the four chemistry teachers in-serviced by the National INSET Unit in Chui District and three in Simba District because one was deceased. One cluster in-service educator, educated at the district level, was selected in each district. This gave a total of nine participants in-serviced by the SMASSE project for the study. The purposeful selection of the SMASSE project in-serviced teachers who were still teaching chemistry in the pilot districts ensured that the study participants were in the best position to provide adequate data that met the purpose of the study and answered the research questions.

Researcher’s Role

In this study, I saw myself playing the role of an insider-outsider researcher (Kvale, 1996). I played the role of an insider because I was born, went to school, was educated as a teacher, taught high school mathematics and chemistry, taught college chemistry, supervised pre-service science teachers, and was in-charge of the chemistry in-service teacher education in the SMASSE Project in Kenya, from July 1998 to August 2001. As the person in-charge of the SMASSE Project administration, I was technically the deputy head of the National INSET Unit. I was also a member of the secondary course panel at the Kenya Institute of Education, a curriculum development center, from 1998 to 2001. A good number of the participants at the national INSET were my former schoolmates, university classmates, former pre-service student teacher at the Kenya Science Teachers College, fellow examiners, or professional colleagues. During field trips, I had a chance to visit the pilot districts and schools in which the SMASSE chemistry teachers were stationed. In the course of our in-service activities, I had a chance to interact with the principals and science teachers in the pilot districts and developed rapport among them.

I saw myself as an outsider researcher because I went back to Kenya from the United States of America to conduct research after being away for more than two years. Having had further studies and education in Britain, Japan, and in the United States, I was an outsider to my colleagues in many aspects. Professionally and academically, I have different and higher qualifications in science education compared to them. Having interacted with many international scholars, my way of interpreting and making meaning of phenomena in Kenyan contexts was likely to be a bit different from that of many of my colleagues whose experiences were based on the Kenyan contexts and the international news they come across in Kenya. I had advanced myself in qualitative research methods in education and with the education I had received in the United States, my outsider researcher's role was likely not to affect collection of trustworthy and credible data from my chemistry teacher colleagues in Kenya. I had to maintain my professionalism in research work. My insider-outsider researcher's role was likely to uplift my research process and interpretation of the collected data. My subjectivities, as a person born in Kenya and as a qualified science teacher with teaching experience in all levels of Kenya's education system including teacher education, were an asset in my research. I was able to reach the participants and conduct the research, analyze and interpret data professionally. I was in a better position to identify the meanings that the teachers attached to their beliefs and experiences in designing and implementing chemistry unit lesson plans following their in-service education programs.

During the data collection and analysis process, I played a role of an observer and interviewer. I pre- and post-interviewed the teachers on their experiences in designing and implementing chemistry unit lesson plans following their in-service education programs. I observed the teachers teaching their chemistry classes during the data collection period that started in mid January 2004 to the end of February 2004 on a weekly and daily basis. Because of the participants' tight schedules (being classroom teachers and heads of departments or schools), some interviews were conducted during the weekends.

Reflections on data collection. As an insider, I did not anticipate any problem during the data collection in Kenya. I arrived in Nairobi at night. The following day I paid a courtesy call to my principal and proceeded to the Ministry of Education, Science and Technology to apply for the research permit. I was well received by the Ministry officials. They were happy to learn that I used to work for the SMASSE project and was conducting research on it. This prompted them to prepare my work permit within one week, a process which usually took a minimum of two weeks. My next move was to collect documents on the SMASSE project activities from the national in-service education unit and information on where to locate the district in-service educators. However, I was disappointed to learn that my colleagues treated me as an outsider and refused to part with any information about the project. Having been one of the pioneers of the project and one of the subject administrators for three years prior to my graduate studies at The University of Georgia, I felt let down by my colleagues in administration. They had even ensured that I had been replaced despite my being on paid study leave from the Teachers Service Commission.

My knowledge about the pilot districts and the in-service teachers assisted in my purposive selection of the study areas and participants. I was able to locate the participants in the selected pilot districts. The pilot districts were far from the capital city, while some schools were inaccessible by car during rainy seasons. This made me to plan my data collection in some schools based on the weather conditions. On arrival in the schools, I paid courtesy calls to the principals, where applicable, to let them know of my mission in their schools. However, four of the schools' principals were participants in my study. Those who volunteered to participate in the study signed the consent forms with my assistance. I assured them of their confidentiality and use of pseudonyms in the findings. The participant names and schools given in the research findings of this study are pseudonyms.

Having been a colleague of the participants, we had a rapport throughout my data collection period. It was easy for me to converse with the participants as I was able to speak to the participants in our national language, Kiswahili, or in English depending on the subject under discussion. In addition to daily data collection and having only one and half months to collect my data, I conducted some of my interviews during the weekends or after school. Kenya has a national spiral chemistry curriculum for grades 9 to 12. Chemistry has four lessons every week of a school term in each class. Schools time table the teaching of chemistry at different times but each week must have four chemistry lessons. This arrangement made it easier for me to collect the participants' time tables and develop a master time table for data collection from schools. It was possible for me to arrange to visit two schools in a day and collect data from two participants daily for all the days I was in the field.

It was easy for me to keep in touch with the participants to let them know when to expect me because they had mobile phones that were accessible even in the remote areas. The use of the cellphones greatly assisted in data collection. Where I was not able to immediately record the teachers' lesson reflections following class lesson observations, we agreed with the participants when I had to go back for them. These arrangements sometimes made me to reach my residence at night on several occasions. Many of the participants used public means to school. In some situations and because I was responsible for the participants delay, I had to drive some of the participants to their homes, an exercise I had not thought of during my research design.

The participants are used to answering questionnaires, as such, they found my qualitative research data collection methods demanding. One participant openly wondered why I was wasting his time instead of giving him a questionnaire to fill. The principals frequently reminded me that it was a great honor for them to spare time to attend to my interviews and giving reflections on the lessons they taught. Three of the participants were frequently being called by their principals as I conducted the interviews. In many situations we had to pause and start from where we had left after the participants attended to their other school duties. One of the participants had to be given special permission by her principal to leave a workshop that was being held in her school for my one-hour interview. I felt humbled by the principal's gesture, especially when I was told why she allowed the participant to leave a workshop that meant so much to the school. She was one of those principals who value the role of research in education activities.

Initially, I thought it was easy to organize a focus group interview. I realized from the first day in the field that I was dealing with a group of participants that were difficult to assemble together at any given day. The focus group interviews were the last parts of my data collection arrangements. Through negotiations, I was able to have three of the participants from each district available for the focus group interviews in the respective districts' hotels. Although my participants were well known people in the community, I conducted the focus group interviews with minimum interruptions. During the focus group interviews, I organized for the meals and drinks as a way of saying thank you to my participants.

However doing research in Kenya, one has to be patient with the interview times. Sometimes the interviews or class observations were postponed or cancelled at the eleventh hour depending on the participants' other school commitments. Although the participants attended the interviews as agreed, one should always be prepared to start them anytime after the agreed time, what one may call "African time." The good thing is that once the participant agrees to your request, he or she will always attend to you regardless of the time you are to wait. I was fortunate to deal with participants who had many responsibilities in their schools. It was a good learning experience as I took my first step into a major qualitative research study in a non western "less industrialized" country. A research setting where some of the western lenses through which one may conduct qualitative research may not be applicable. One has to conduct the research from the participant's perspective and not that of the researcher. The cultural contexts appear to support crystallization of data as opposed to data triangulation in the focus group interviews.

Data Collection Methods

After obtaining an approval from the University of Georgia's Institutional Review Board (IRB) to conduct research on human subjects, I sought permission to conduct research in Kenya's public schools from the Ministry of Education, Science and Technology in Kenya in January 2004. Upon arrival, I requested the selected teachers in the selected two districts to volunteer for the study and let them know that their confidentiality was to be maintained using pseudonyms (see Appendix A).

I used individual interviews (Kvale, 1996) and participant observation (Emerson, Fretz, & Shaw, 2001) methods to collect data from the selected in-serviced chemistry teachers during the months of January and February 2004. I also collected archival data such as lesson plans, chemistry education syllabus, and the teacher's lesson notes for the some of the observed sessions. Specifically, I interviewed the selected teachers using semi-structured guideline questions (Appendix B and D), individually and in focus groups (Gubrium & Holstein, 2002; Kvale, 1996). Each participant was interviewed before and after teaching his/her chemistry lesson(s) and observed more than once based on issues observed and emerging from the post-observation interviews (Figure 4). The participants were also requested to write a reflection journal of the chemistry lessons they taught during the research period and share their written accounts with me. A data collection plan for each participant was developed (Figure 4).

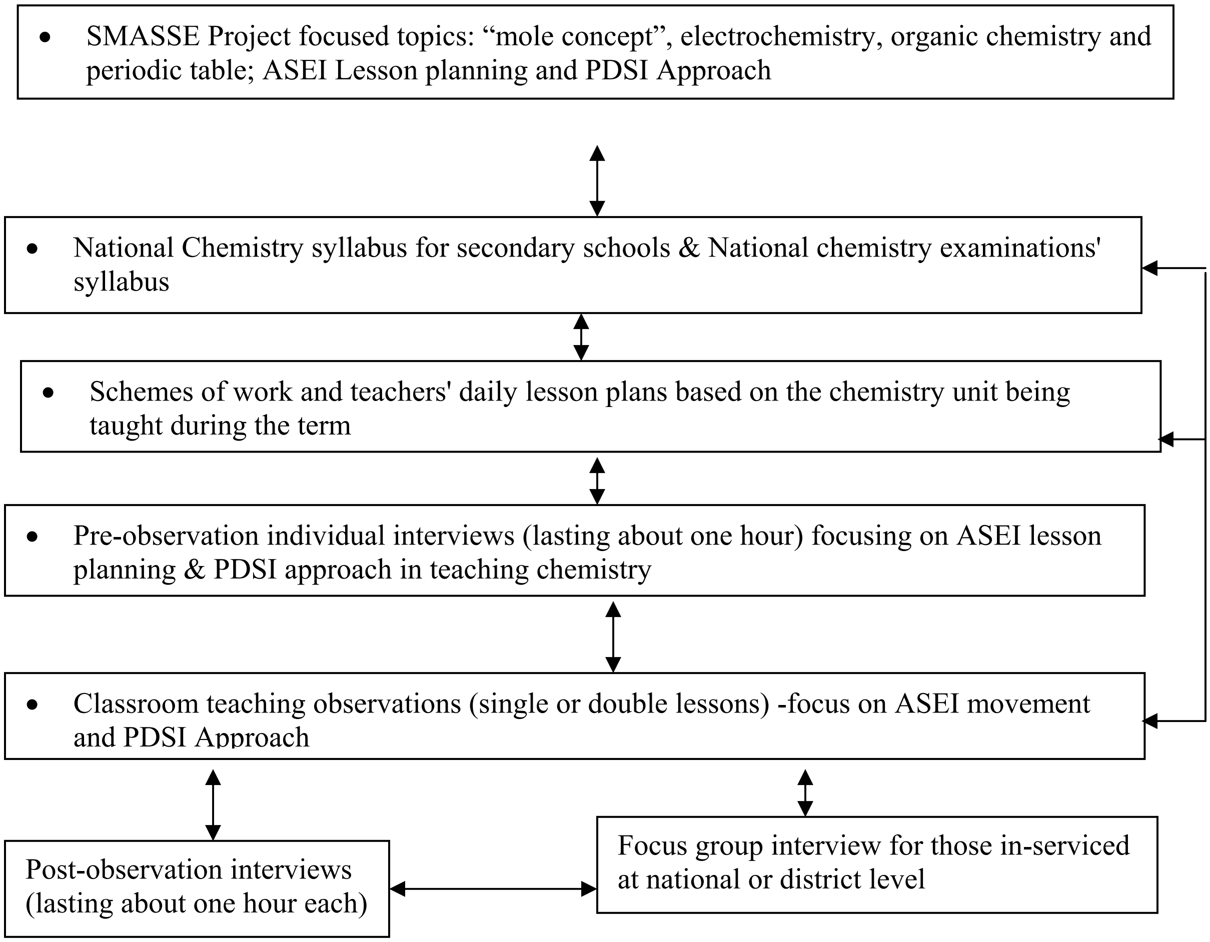


Figure 4: Conceptual plan for data collection

Key: ( ) the double edged arrows show that data collected in the various steps assisted in collecting more data from the other steps or triangulating data collected during the study.

The interviews were audio-recorded. I went through the pre-observation conference audiotapes before the observation sessions to have a feel of the general themes, patterns and categories that I needed to explore during the observation sessions. I used the patterns or categories noted in my observation field notes as probes during the post-observation interview with the participants. Depending on issues generated during post-observation sessions and availability of time, I made more than one observation of each selected teacher teaching chemistry unit lessons during the first school term. I took field notes (Mishler, 1986) during observations which I then expanded during the fieldwork period. Some of the teachers' lesson plans for previously taught and the observed lessons, chemistry schemes of work/syllabus, and list of teaching resources (LeCompte, 2000) were collected during the interviews or observations. I then made copies of all data collected, put the field notes and interviews into a file and floppy discs based on participants and the dates they were created. A file on expanded field notes, lesson plans, teacher's lesson notes, and science education syllabus were kept. All the documents and artifacts were cataloged and stored. This process ensured that all the collected data was accounted for and retrievable whenever needed during the analysis.

A matrix illustrating the connections between my data sources and methods of collection and my research questions is shown in Table 4.

Table 4

A Matrix of the Connections between Data Sources and Methods of Collection and Research Questions

Technique	**Research question 1**	**Research question 2**	**Research questions 3 and 4**
Participant observation	X	X	
Interviews (individual and focus-group)	X	X	X
Audio-tape	X	X	X
Artifacts (lesson plans, schemes of work, syllabus, teacher's notes, etc.)	X	X	

Data Analysis Methods

I transcribed the audio taped data and typed my expanded field notes immediately after collecting data. With constant reference to the research questions, I grouped the codes into categories, patterns, and themes when interpreting the data using qualitative research procedures (Charmaz, 2002; Dey, 1999; LeCompte, 2000; Strauss & Corbin, 1996). I specifically looked for any relationships among the codes or categories. The developed relationships were summarized in the form of tables or figures followed by detailed descriptions and interpretation of the data.

Specifically, I used inductive data analysis strategies (Charmaz, 2002; Dey, 1999; LeCompte, 2000; Strauss & Corbin, 1996), employing open-coding techniques, to reveal regularities in the data. Inductive data analysis strategies that I found useful in my study include "pursuit of emergent themes through early data analysis and discovery of basic social processes within the data" (Charmaz, 2002, p. 677). Other helpful ones involved "inductive construction of themes that explained and synthesized the social processes, and integration of categories into a theoretical framework that specified causes, conditions, and consequences of the studied processes" (Charmaz, 2002, p. 677). In addition to appropriate use of traditional teaching methods, I expected the in-serviced chemistry teachers to prepare their lesson plans following the SMASSE Project format and teach according to SMASSE's PDSI approach. However, teacher's beliefs, national examinations' requirements and the school community seemed to dictate the chemistry lesson plans' preparation and implementation in the study districts regardless of the teachers' exposure to SMASSE in-service programs in Kenya.

I started analyzing data using open coding strategies (Charmaz, 2002; LeCompte, 2000; Strauss & Corbin, 1996). The initial open coding helped me to start making analytic decisions about the data. During my data coding process, I studied the data before consulting any scholarly literature for theoretical themes, patterns or categories applicable to my data. I then labeled and organized my data using simple and general coding systems by looking for leads, ideas and issues in the data, and engaged myself in line- by- line coding (Charmaz, 2002). Through careful line-by-line coding, I looked for processes, actions, assumptions, and consequences in the data. I used active terms to define phenomena in the data and link specific statements in the transcriptions to the main processes that affected the participants' designing and implementing of ASEI chemistry unit lesson plans. Focused coding followed the line-by-line coding. During the focused coding process, I used the "most frequently appearing initial codes to sort, synthesize, and conceptualize the collected data" (Charmaz, 2002, p. 684). This assisted in generating several categories for the interview data.

The coding process further helped me to establish the relative emphasis participants placed on various issues regarding their experiences (LeCompte, 2000) in teaching chemistry following in-service “training” programs. This made it possible for me to develop the connections between participants' situations and interpretations of their beliefs and experiences. The data open coding was triangulated through member checking. In addition to member checking during data collection process in Kenya, I was assisted by some of my doctoral committee members at the University of Georgia. My major professor, Dr. Norman Thomson, had vast knowledge on Kenya’s public school system. I used my colleagues' feedback and my initial open coding to do focused coding (Charmaz, 2002) in which I categorized the codes based on participants' natural language and my research interest. I also wrote elaborate descriptions of the categories (memos) and integrated the memos (Charmaz, 2002; Strauss & Corbin, 1996) to reveal the relationships between categories. This helped me to identify the themes (LeCompte &

Preissle, 1993; Ryan & Bernard, 2000) within participants' told story on their beliefs and experiences in teaching chemistry unit lessons following their in-service courses in Kenya.

CHAPTER 5

MULTI-SITE CASE FINDINGS FROM SIMBA DISTRICT

In this section, individual and focus group case findings from the participants (Moja, Mbili, Tatu, Nne and Tano), who were teaching in different school settings (boys' boarding, Girls' boarding, mixed boarding, and mixed day) in Simba District, are presented. The participants' class sizes ranged from 40 to 50 students, depending on the school category. District schools tend to have a large number of students in class. In Kenya, secondary school science teachers teach across the forms (grades 9, 10, 11, and 12) using a national spiral model curriculum. First, the individual case findings for Moja, Mbili, Tatu, Nne and Tano, based on individual interviews, class observations and teacher reflections, are presented. The individual participant cases are followed by findings from a focus group interview in which Moja, Mbili and Tatu participated. A summary of the findings is included at the end of this section. The following are the findings from Simba District for all the five participants, starting with Moja.

Moja

Teaching background. When Moja was in high school, he never thought of becoming a teacher. He studied mathematics, chemistry and biology during his advanced level education. He had wanted to take different courses, but after high school he was selected to university to take education. At the university, he opted to take chemistry because he had realized that he liked it more than biology. Although Moja liked mathematics more, he found chemistry had more application than mathematics in day to day life. And he also thought that after college, he might take some more courses which will lead to knowing more about chemistry and becoming more of a scientist.

He had been inspired by the works of some scientist such as Rutherford, J. J. Thompson and Albert Einstein. Moja felt that he did not know of any people in mathematics that made him want to do mathematics. At the university, the chemistry content was the same whether one was to be a teacher or to go to do some chemistry elsewhere. But to become a chemistry teacher, one had to do education courses such as methodology of teaching, history of education, curriculum development and implementation. Moja felt that college education was more theoretical because they had almost three years doing theoretical work. And it was only one semester, which comprised of four months that he was able to put what they were taught into practice. He felt that it was difficult to correct errors made while one is in college because there was no second chance for the teaching practice.

At the time of the study, Moja has taught for 13 years. He began his teaching career in a girls' school. He taught mathematics and chemistry in the girls' school for approximately three years before he was transferred to the boys' school in which he had been teaching for 11 years. In the girls' school, he was more involved in the teaching of mathematics than chemistry. For 11 years, Moja was mainly involved in teaching only chemistry.

Moja's chemistry teaching before the SMASSE Project in-service program. Moja noted "…as a teacher, the content I had. I have the content." However, his chemistry teaching before the SMASSE in-service program was more theoretically oriented and teacher-centered. He was more concerned with covering the syllabus than involving the students in generating knowledge on their own. He would occasionally give a bit of assignment to make the students to dig deep more into areas that they were learning. He did not have the students set their own experiments. So much of his chemistry teaching was exam-oriented. He was more concerned about students' ability to answer the national examinations questions and pass. According to Moja:

> ...It was a question of teaching, pass the knowledge, students make notes most of the time, and actually if you go to some of those notes they are not SMASSE-oriented. You will be more making notes than you will even find a lot of chalk dust on the hands, which implies that the teacher is doing more writing than the students' activities that they are doing.

Moja used to perform teacher demonstration experiments and sometimes could avoid doing some experiments because he thought that they were dangerous to conduct in class. In relation to class experiments in chemistry lessons, Moja said that:

> ...I was the one doing the experiment and the students were making the observations. And there were so many other experiments where a teacher will actually leave those experiments, because that is me now, where you think that some experiments are dangerous, maybe this could be explosive experiments like probably producing hydrogen and trying to burn it. And I can tell you here that at one time I tried that hydrogen and it was really explosive. So those experiments I had to forgo them and give an excuse of maybe doing them later and when I realized how dangerous it is, even if the students asked for it, I will not go back and do the experiments.

The broad secondary school curriculum and the examinations-oriented education system in Kenya influenced Moja's behavior in lesson preparation and implementation. Moja's teaching concern was mainly to cover the syllabus and have students able to answer the national examinations' questions. Moja said:

> ...I was looking at covering the syllabus. So if I realized that giving the students a class experiment was going to take a lot of time, I could demonstrate or all together did the activity, so that I continue to complete the syllabus. And I think further than that, teaching this chemistry was more oriented towards answering questions. So much of the time you find I was giving in questions from mostly past papers and trying to see how a question can be set in a topic. But in the real sense, I did not have that sense that the students should have the knowledge rather than answering the question, even when they did not understand the knowledge behind what they were actually doing, that is, they may not have understood the concept but they may have known how to answer the question because that, maybe crammed. But they did not internalize and understand the real concept behind that question.

While his goal/concern was to cover the syllabus, Moja did seem to be aware of a tension-the students may be able to answer a question but not necessarily understand the concept.

Moja uses the Kenya National Examinations Council (KNEC) syllabus and that from the Kenya Institute of Education (K.I.E) in designing his lesson unit plans. Moja said that "when you use the syllabus, it is assumed that what is in the syllabus is the only thing that is supposed to be tested. So you look at the syllabus, but to the extent to which you are to cover the syllabus, sometimes is not defined." The K.I.E syllabus does not therefore show how far one has to go into particular areas, but the teacher decides content depth and what is relevant. According to Moja:

> The K.I.E syllabus has given the objectives of what the students should know and what is going to assist them to do, for example, if you are teaching a certain topic, what is this going to assist the student do after school? So we have the immediate objectives, the ones of realizing what a student should do out there in class and then what a student will do after he leaves this institution. So that one seems more elaborate than the one of the Kenya National Examinations Council. So we tend to use the K.I.E although even that one it is the teacher to decide how far he will go because you have to look for now any related knowledge that can assist the student to understand something that you have.

Although Moja had the national chemistry syllabus and the national examinations requirements, he made decisions on what content he had to teach his students. He made such decisions to ensure that his students understood the chemical concepts he taught.

The examination-oriented education system in Kenya influenced Moja's choice of teaching activities that are teacher-centered instead of student-centered. Moja argued that:

> …this content which I presume is the knowledge, which I am passing to the students, eh I may not look at it from the perspective that the students themselves should understand this knowledge but I am looking at the fact that I want the students to pass by whichever means is immaterial. So either they cram this knowledge the way it is. And this, you know, makes the students even have very poor analytical abilities because given knowledge and they are told to relate to this, then they are unable to answer. And probably that is the reason why the students, although I looked like I was really trying, the students ended up failing because they didn't understand what they were being taught. So, passing this knowledge to the students, the methods to enable the students understand what I was giving them, I think were not appropriate.

From the excerpt, it can be inferred that prior to the in-service education program Moja really had a shallow epistemology that is fostered/supported by the examination-oriented education system.

The major benefits Moja received from the in-service program. Moja was recruited to join the in-service project as a district educator through an interview conducted by the local district education board representatives. He attended all courses conducted by the national SMASSE INSET Center during the months of August from 1999 to 2002. He was involved in the in-servicing of chemistry teachers at the district level during the month of April and at the cluster level during the months of August from 2000 to 2003. Moja felt that he had benefited from SMASSE in-service program in a number of ways. As a teacher he benefited in changing his attitudes towards the teaching of chemistry. The change of attitude has permeated further into other departments within Moja's school. On the role of SMASSE in-service programs in changing his attitudes towards students' learning activities and involving other teachers in school, Moja said:

> …it has also made me to change the attitude of the other teachers because I can argue pro-SMASSE. That is what SMASSE was giving us. I also try to pass it to other teachers who may not even be in the chemistry department. They could be even in math department, biology or physics, which actually in this school now, it has even gone to the English department, where they expect to give students a lot of activities the way the SMASSE says it.

Moja was able to prepare student activities, projects, and experiments using locally available materials. He was able to involve the students in learning activities than before he was in-serviced by SMASSE project. According to Moja:

> …SMASSE has really assisted us in terms of getting activities that involve designing projects for students, getting activities for students, which we used to have been very limited. And SMASSE also has made us to do some activities which could not be done before because we thought that, may be, all the time we should use materials which are

> conventional but currently we can use any sort of materials that we have within reach and the students are able to use them and understand the concepts that we are passing to them.

Following the in-service courses, it seemed Moja was able to plan and implement his chemistry lessons with ease. He incorporated the student-centered activities in his teaching. Moja noted:

> …when SMASSE came in, it has even made my work easier because most of the time I am no longer writing and I am not having a lot of chalk dust. Now I am able to give activities to these students and I am even to make them go further by asking them to design some projects, which actually in this school now, you can see how much the students are even participating in the science congress.

Moja felt that he had the chemistry content knowledge and the only thing he learned from SMASSE that he did not know before was new teaching strategies in chemical education. This had enabled him to prepare teaching/learning activities that focused on students. Moja said that:

> …much of what I learned was to do with the teaching methodology. But I can not say that I learned chemistry knowledge from SMASSE. All that I learned was how to impart this knowledge effectively to the students that is what I learned from SMASSE. Eh, given that mine was initially lecture method, but from SMASSE I am able to learn that more, students will learn when all the methods are combined. And more so when the students are involved in attaining this particular knowledge especially experimental work is very important and project work

It seemed the SMASSE project had made Moja to have a change in his epistemological orientation about teaching and learning in chemistry.

Moja planned activities with the students in mind and their subsequent involvement in lesson activities. In Moja's words:

> The method these activities have been given from SMASSE, how to go looking for the activities that will make the students, I think that is the core part, that you get the activities which the students will do and then they question the results and in the process of questioning this result they will tend to understand the concept or the idea behind what is happening. And this has made the students able to answer many questions because however much the question is twisted, a student can know actually what is behind the question.

The new classroom environment created by Moja following the in-service programs was meant to assist his students to learn chemistry concepts, which were difficult to comprehend when he taught them using the traditional methods. Incorporating new teaching strategies in his chemistry classes meant that Moja had to change the way he designed his chemistry unit lessons. In the following section, findings on Moja's chemistry unit lesson designing are presented.

Moja's designing of chemistry unit lessons. The SMASSE lesson plan format has three main parts: objectives, activities, notes columns. The format was supposed to be easy to make and implement. Moja found chemistry unit designing following the SMASSE format as being teacher friendly but laborious. He said that:

> I would say that, although designing the lesson plan,…could be friendly but it is laborious on the teacher because when you are planning this lesson, you have to really plan for the lesson…as a teacher, you have to go round seeing what the student can do, making it, actually, it is laborious on the side of the teacher to get as many activities as possible, which was unlike the case.

Although lesson planning and preparation required a considerable amount of time on the part of the teacher, Moja found it easy to implement the chemistry unit lesson plans following the SMASSE in-service program. He said that:

> …when the lesson is on it is now easier for the teacher than it used to be because at that time the teacher was more involved in class. This time now it is the student who is more involved than the teacher. So..., especially the implementation of the lesson plan, it is easier than preparing this lesson plan. The part of implementation is easier for the teacher but in the planning, the teacher has really to go and do a lot of research to see what is to be for the students.

The lesson implementation had become easier because Moja incorporated student activities in his lessons and avoided having teacher-centered lessons.

Changes Moja made in the design of subsequent chemistry unit lessons. Moja had made changes that he felt were important in terms of lesson designs that incorporated student-centered teaching methods and activities. Moja said that:

> I have changed from having a lot of load on the development, not actually, I can't call it a development on the notes themselves. And the lesson now has shifted to where we have activities… we should have a lesson more student-centered than the teacher-centered. That has made the part for activities to increase so that I have more on activities than on this other just notes part or something like that.

The SMASSE in-service program had made Moja to change the way he planned for chemistry lesson evaluations. The incorporation of assessment components during the planning stage had assisted Moja in improving on subsequent lessons. In Moja's words:

> …before I did not have the idea of evaluation because all that I called evaluation was actually to give the students a test at the end of a topic or at the end of the whole term. And with SMASSE, I am able to have the remark column now, with that modification, I am to evaluate the students and make remarks immediately. So this is unlike before… So when you make immediate evaluation. It means that you can go back and even redesign the lesson and improve even the activities that you have given the students that they have not understood, so that you can increase the activities and see the most appropriate activities that may be you might have overlooked. And then you also see whether it is you who passed the message in the wrong style.

Moja, further, observed that:

> …the redesigning of the lesson arises from the fact that the teaching methodology is what had failed me before. And when we are teaching, we are talking about teaching methodology, I think you are also looking at, that is, the knowledge and the way it being imparted. These alone brought a lot of change.

Moja redesigned his lessons because he felt that his teaching methodology needed change following the SMASSE in-service teacher education program. Moja seemed to have reconsidered what it means to learn and how that view is represented in teaching methods.

SMASSE's influence on Moja's implementation of chemistry unit lessons. Before the SMASSE In-service program, Moja used to find it very difficult to teach the periodic table. Previously, he could carry the periodic table chart to class as a teaching aid. Following the in-service courses, Moja made the students to design something that appeared like the periodic table. From the interviews, class observations and lesson reflections, it seemed Moja at least had activities for the students to design and make their own periodic tables. Moja even had his students make some periodic tables using soapstone (which is readily available in the neighboring district). Moja involved his students in using beads or locally available materials such as Sodom's apples, beans, peas, or maize to make a periodic chart.

In the electrochemistry area, Moja involved the students in conducting class experiments unlike in the past where he used to cover this topic through teacher demonstrations. With improvisation, Moja was able to carry out many experiments, especially where the students were collecting gases such as hydrogen and oxygen from electrolysis of dilute sulfuric acid. He made his students to do experiments involving electrolysis of sodium chloride and brine, and they were able to observe the products conspicuously. In electrochemistry, Moja's students were involved in a variety of learning activities. Moja was able to demonstrate electrochemistry concepts using improvised materials such as using a tissue paper as a "salt bridge" in electrolytic cells. The tissue paper worked perfectly. According to Moja,

> The tissue paper...all that we do is to make a solution of potassium nitrate, which is actually the one being used in the "salt bridge". So you will immerse that tissue paper in that potassium nitrate solution. Then using two beakers, you are able first you will have the obvious external wire, then now at the part of the "salt bridge" you will place part of the tissue paper in one beaker and the other part in the other beaker. And immediately you place those ones like that you will see the movement on the needle of the voltmeter. So it works actually very well. So we could….say that one has served very well. So where we don't have something like a U-tube or something like that, a tissue paper can do, even a serviette can do any absorbent material that can really absorb something that works very well.

Through improvisation, he was able to plan for students' experiments that were not being done previously because of inadequate equipment and chemicals or belief that a given experiment was expensive to conduct or was dangerous to perform. The teaching and improvisation skills assisted Moja to be able to cover the high school electrochemistry content with ease following the SMASSE in-service teacher education programs. Moja was able to plan many student experiments in electrochemistry. He had experiments in which he was able to show movements of ions which they never used to do before the SMASSE project. Following the in-service program, Moja was able to demonstrate the movement of ions, for example the hydrogen ions, using red cabbage to show that when one connects the batteries the indicator will be decolorized towards one direction, while the other direction is not decolorized. Moja said:

> Changing the indicator in acidic, may be if you are using an indicator which turns may be pink when in acidic media then as the hydrogen ions are moving towards that direction then you are able to see very clearly what is happening, and that will show clearly the students the movement of those ions, once the circuit is complete. So this has really assisted us.

Moja said that organic chemistry had been an area that was sometimes very difficult for the students. Following the in-service program, Moja was able to involve his students in performing experiments such as making soaps and esters, and combustion of various alkanes in the laboratory unlike before the SMASSE project. He was able to have his students do fractional distillation of crude oil in the school laboratory. He felt that SMASSE had really influenced him because he was able to go very deeply into finding activities that the students can do and in the process, he found that he had many activities for the students to do and improve on their grasp of the scientific knowledge.

Moja's students were able to analyze beer in the laboratory. He was able to assist his students to observe the effect of beer when using some particular indicators such as potassium permanganate or potassium dichromate in the laboratory. He was able to apply the chemistry that the students were learning in school to their everyday life experiences.

Although the "mole concept" had been actually the one most difficult topic for the students to carry out in terms of experiments, Moja thought that he had been able to plan class experiments where for example the students are able to experimentally determine the empirical formula of a given compound. Moja's students are able to determine for example the empirical formula of copper (II) oxide experimentally. They are able to do many analytical experiments in which they determine the chemical composition of given substances. In addition, Moja made his students to determine the percentage impurity in a substance such as calcium carbonate through analysis.

Changes Moja made in the implementation of his subsequent chemistry unit lessons. Prior to the SMASSE in-service program, Moja sometimes viewed his teaching in terms of "going to class, coming and moving out." He took time management and evaluation during lesson implementation seriously. He had to think about "…the way the lesson starts, starting it on the dot and then after that continuing to teach the lesson. At the end of it…be able to see whether you over prepared or you did not do that." Moja used to make sure that if he had a practical session, he had to do the experiments first, to ensure that they were working before giving them to the students to do in class. Moja noted that:

> …So before I take a lesson to class, I ensure that this particular practical will work for the students. It is not something we are going to try with them that may not work and therefore waste the entire lesson. So it is something that one must do.

However, following the in-service program Moja ensured that his students were really involved in his lessons. Even where there were no experiments for the students to perform, Moja made sure that the students were involved in minds-on activities and with flexibility, the lesson is implemented as planned. Moja said:

> Where there are no experiments then I make sure the students have activities. This could be what they call in SMASSE some may be minds-on, or it could be having other

> activities like brainstorming. You know, you have some students in class and just give them something to discuss so they brainstorm and come up with what they have. But I can say that in implementation of this I think it has not been much of a problem because all I have if everything is there then it is the teacher to go to class and ensure that the lesson runs as planned.

On changes made during instruction, Moja put it:

> …you may teach and…you find the students do not understand. So if you are in class, and then you are teaching, then you realize that there is some knowledge that students require to understanding the present concept, then, you have no choice except to revisit what that knowledge, because it now becomes a prerequisite. They have to have that particular knowledge to understand this concept that I am giving them. So I have to go back and immediately teach what the students would have known to enable them to understand what I am teaching currently. So should I make any change, then it has to be done and to be implemented there and then because you know you can not come out of class and say let me go back and prepare.

Through lesson evaluations, Moja was able to make changes during instruction. Moja made changes in his lesson content whenever he realized that his students were not following what he was teaching. He had to revisit the students pre-requisite knowledge that would assist them learn the new concepts he taught. It seemed Moja thoroughly prepared for his lessons, which assisted him in teaching any chemical concepts to meet his students' needs in class.

The SMASSE Project planners: Considerations for future in-service courses. Moja thought that the SMASSE project organizers must take care of the teachers' attitude towards the project when they are planning. Teachers view project as "a sign of may be "big" things to come rather than improving on their teaching." Teachers should be made to understand what they expect from an in-service program right from the start. Teachers expect to be recognized in one way or the other following in-service courses.

Moja believed that "teachers have the knowledge and they went through college and therefore they are not ready to change. They don't believe that there are new changes in teaching methodology." The teachers have to understand that they are in a changing society in which new methods of teaching and learning have to be incorporated into the science education classrooms. Moja felt that in-service programs ought to be implemented by professional teachers who are involved in education. Moja argued that “actually the SMASSE project involved the parents because they provided fees, from which the inspectorate collected money to run the project. However, the inspectorate is not on the ground, so they don't know what problems the teachers being in-serviced are undergoing.” In this regard Moja felt that the SMASSE project planners should deal directly with the in-service education centers and ensure that there is adequate provision of facilities and appropriate administrative structures to avoid unfair treatment of teachers during the in-servicing sessions.

The district INSET center libraries should be equipped with methodology books instead of content ones as it was the case. According to Moja,

> The library…for SMASSE “training” should have more material on methodology rather than the content because essentially a teacher has the content. What the teacher needs, like if I…from the chemistry part, I can tell you that this our library does not have any single book on the teaching of chemistry…So if they can, may be, provide books for teaching methodology, testing and so on, then it could be better.

Moja felt that there should be more in-service courses. The planners should have more in-service courses running throughout the year with adequate follow up activities to ensure that what the teachers are being in-serviced on is implemented in schools. Moja argued that:

> ...although they have brought the idea of good teaching methods they should ensure that they go actually to the ground, and then see the teachers teaching. That is **very, very** important because no sooner have these people attended this SMASSE project than they go back to their old methods because they are not kept on toes.

The in-service teachers found SMASSE’s approach to science teaching good. However, it seemed monitoring and evaluation of in-service teachers’ activities was lacking in the districts.

Moja observed that:

> …Then the SMASSE team will in-service this particular teacher who is indifferent even to education. He really feels that he will not become a teacher and he doesn't care about the SMASSE Project…So may be the people who are supposed to be in-serviced to start with must be teachers by profession or people who are going to remain in the field for a long time and would not be disturbed by going to other different courses or moving out.

Effective monitoring and evaluation activities would assist the in-service planners to realize that they should spend money in-servicing professional teachers and not people who are temporary in the profession. Unqualified teachers interested in teaching ought to have a different in-service program from that of the professional teachers.

Moja observed that the SMASSE planners should not assume that teachers used the materials delivered to the District INSET centers. Some of the equipment requires technical knowledge on how to operate them. Teachers should be in-serviced on how to operate such equipment to avoid having them lying redundant in the centers. Moja said that, "…the SMASSE project should not assume that the materials that they have brought, the people who are in-servicing know how to use them. And they should also make a follow up and see that these things are being used."

In-servicing teachers on INSET materials management and utilization will ensure accountability and justification of the materials provided to the district INSET centers. This is likely to enhance teachers' skills on how to operate science equipment they are not familiar with, and thus improving on the teaching and learning of high school chemistry in Kenya.

Mbili

Teaching background. At high school, Mbili was very good in the sciences and when she found that there was a chance at Kenya Science Teachers College, she applied and was selected to join the college after high school. At college, Mbili found that she liked chemistry more than the other sciences. And that is how she decided to be a chemistry teacher. She was prepared to become a good chemistry teacher at The Kenya Science Teachers College. Mbili said:

> …when I compare what we learned at Kenya Science Teachers College with what other colleagues did in other science teacher education institutions, I think we were very well placed because we had a good time. We had a lot of practical work and we did a lot of experiments, a lot of theory work and I thought we did quite a lot; especially the practicals and I enjoyed it so much.

However, when Mbili joined teaching in 1973, she had not thought about the teaching profession seriously. She started teaching in 1973. She started teaching in a girls' school in which she taught for nine months before she was transferred to a boy's schools in another district where her husband was teaching. She taught in the boys' school for about two and half years before she was transferred to another girls high school within the district in which she taught for another 4 years before she was transferred to another girls school in a neighboring district in 1979. She taught in this school from 1979 to 2004 before she was transferred to a mixed school. In all, Mbili has a teaching experience of 31 years.

Mbili's chemistry teaching before the SMASSE Project in-service program. Before the SMASSE in-service programs, Mbili thought that her teaching was good even though sometimes she could just teach theory lessons. The preparation she had received at college guided her in planning and implementing class experiments. Mbili said "… because of the way I had learned earlier on, you know, in my school we were doing a lot of practicals and from Kenya Science Teacher College, of course, I was doing some practicals." Mbili used to have her students do many experiments in any chemistry topic that was required unless the experiments were dangerous to perform. These experiments relied on the procedures given in the class textbooks. On class experiments, Mbili said:

> …I think I was doing experiments except I was trying to avoid the dangerous experiments. But the experiments I was doing in most cases I was just following the

> experiments in the textbook. So it was sort of "recipe type" of teaching and the experiments I did were many anyway, at least I know I did most of the experiments that were in the textbooks.

However, there were instances in which her teaching was theory-centered with no student activities to make the lesson more enjoyable and interesting. Mbili had no problem with the chemistry content but her students had to answer teacher's questions and writing notes as the lesson progressed. Mbili noted that:

> …I didn't have some activities that were not mainly practicals, demonstrations and when it came to the content, I think I had no problem with the content, except there are some topics that the approach was so difficult, like the "mole concept", the students didn't like it. Like the electrochemistry we used to have mostly theory, like the organic chemistry we used just to handle it theoretically and so I thought it wasn't so good. And when it came to the instruction methods, I think mostly it was just chalk-lecture method without allowing the students to do a lot of discovery.

As a professional teacher, Mbili used to take part in in-service courses. She used to be very active as far as the activities in sciences were concerned, especially in Simba District. So when it was announced that there was a science project to in-service teachers, she became very much interested because she wanted to know more and improve her teaching. She decided to apply, and attended an interview through which she selected to participate in the in-service program as a district SMASSE project educator.

The major benefits Mbili received from the In-service Programs. Mbili felt that she has benefited from the in-service programs in terms of lesson planning and preparation that focused on students. Although she felt that student-centered lesson unit planning required considerable amount of time to prepare, Mbili said that:

> …I learned that when you are preparing your lessons, you have to think of the activities, you have to have the student in mind. And so that is something that I learned. I also learned that when you plan your lesson very well, with a lot activities, the students will enjoy the lesson and in class, you know, you don't even talk too much.

Mbili also felt that she did not have adequate prior knowledge on the various SMASSE Project activities for students to do especially where there were no class experiments. The student activities covered during the in-service program made Mbili “really happy”. In her own words, Mbili said:

> I didn't realize that in a chemistry class, you can have a debate. I didn't know that in a chemistry class you could have a crossword puzzle, or I didn't even realize that you can have comprehension. But now I know that those ones are there and they make students active.

From the interviews, it was evident that Mbili benefits included improved lesson unit planning and preparation in which she was able to incorporate students’ activities in all her chemistry lessons following the SMASSE in-service programs.

Mbili’s designing of the chemistry unit lessons. Following the in-service programs, Mbili prepared her lessons based on the “ASEI” movement. In the ASEI movement, she focused on hands-on and minds-on student-centered activities with more emphasis on experiments, and where her school did not have conventional apparatus she had to improvise using locally available materials. Her lesson unit plans catered for individual differences in class. In designing her chemistry lessons following the in-service courses, Mbili said:

> …after the SMASSE, I think my lessons now are well prepared because of the "ASEI". Before I prepare the lesson I have to think about the class I am handling and I have to think about their standard. I have to think about the individual per a student that I am having. And so when I am preparing, I am thinking about individual students, how I am going to help so and so. Like now I have realized that there are students that are very sharp, there are others that are very low, so in my preparation I must think how to cater for the bright ones so that I don't bore them. And I have to think about these low achievers so that I don't leave them behind. So after the SMASSE project, I think my students are enjoying because when I prepare I cater for every student.

In Mbili’s ASEI lessons, she planned in advance on how she could evaluate her lessons in order to improve on her subsequent chemistry lessons and improvise teaching materials when conventional ones where not available. She observed that:

> …in ASEI, I am talking about a lesson, this lesson is full of activity, and this activity is centered on students. After that lesson there is evaluation and after evaluation I have to see how to…and think there is need also…improvisation in that lesson. Because you find in most cases, we don't have the materials we require and so there is a need for improvisation.

Planning in advance on how to improvise and use the improvised teaching aids in science teaching and learning had helped Mbili to improve on her chemistry unit lesson designs that focused on students.

Changes Mbili made in the design of subsequent chemistry unit lessons. Mbili made changes in her lesson unit designs when she found that the students did not understand the science concepts she was teaching according to her original plan. The students' prior knowledge on the topic being taught might be limited and hence need to change the lesson plan to accommodate the students. One has to address the problems that students are experiencing in learning given scientific concepts before continuing with new concepts to be learned. Mbili said that:

> …Now you find that I had prepared a lesson to talk about the periodic table but when I went to class, I found that the students had not even done the atomic structure. So straight away I had to change my lesson and I had to teach about the atomic structure… I had to involve the students in a discussion but unfortunately again there are no textbooks. And so you want to read and then discuss but the students have no materials to refer to…from the structure of the atom, we had to go to the electronic structure before we go the periodic table.

Mbili had made changes in electrochemistry lessons. In another class, Mbili said:

> I had also been told that the students had done conductors, non-conductors, electrolytes, but when I went to that class, I just realized that the students had even not been introduced to the topic. So again I had to change my lesson, design my lesson so that instead of me having a practical lesson on electrolysis of copper (II) chloride, I had to again turn to, I had to make the students again find out about the conductors, find about the non conductors

Mbili had also to make changes in her lesson plans when she was teaching a Form Four (Grade 12) class in which she was teaching about solubility. When making the changes, Mbili said:

> I had planned to teach about the solubility of potassium chlorate, just to find that there was no potassium chlorate in the lab. So I had to change to go to potassium nitrate and here again, you know, the quantities were different. I had to look at the amount of the potassium nitrate that would have to dissolve in the 10 cubic centimeters of water. This was of course a class experiment and it was inconveniencing but finally I think the students enjoyed the lesson.

It was evident from Mbili's discussion that she made changes in her lesson plans to accommodate the student needs, especially where the students did not understand what she was teaching. She also made changes in her lesson plans when the required chemicals or equipment were not available in the laboratory.

SMASSE's influence on Mbili's implementation of chemistry unit lessons. Mbili's chemistry classes enjoyed learning the periodic table. Previously she used the traditional methods of teaching to cover the periodic table. She observed that "…previously you would just go to class and just write the topic there, today we are having the topic of the periodic table, and then you start about the periodic table." Following the in-service courses, Mbili planned for student activities when teaching the periodic table. On one of the lessons she had prepared and implemented, she said:

> ….I had prepared a sample of a periodic table but then on that periodic table, I had not really fixed the elements. I had the structure, the outline of the chart of the periodic table but I didn't have the elements. So after we have talked about how the, you know, periodic table is named, the groups and then the periods according to the increasing atomic numbers. After that I gave now the students…I say now this element has atomic number, can you fix it in the periodic table, and then you see finally the students are able to place them.

Mbili used group discussion as one way of teaching the periodic table. It seemed Mbili assisted her students learn the periodic table through class discussions.

Mbili felt that the “mole concept” was a topic that:

> …the students really disliked so much and have a negative attitude towards it even before the topic is taught to them...The reason is because of the way it was being handled and the way I was handling it myself…I just go to class and say today we are going learning the “mole concept”, and that word the mole itself is very scaring. And then I used to start with now mole you are supposed to calculate the mole and when you are given the mole you need the mass, and then you need the RAM or whatever it is.

Following the in-service courses, Mbili implemented her unit lesson plans on the “mole concept” incorporating hands-on and minds-on student activities. The ASEI-based lesson plans helped Mbili to demystify the “mole concept” that many students had difficulties studying it. On SMASSE’s influence on her lesson unit implementation, Mbili said that:

> …we learned that even before we introduce the topic, that is from SMASSE, the topic in the “mole concept”, you know, you must start it by an activity. Activity for example you want to introduce them to the mole itself or you want to introduce them to the relative atomic masses, you can do the experiments with small nails and big nails and you compare how many small nails will make the same mass as the big nails. And so after that you count the number of nails, you know the students see it as a reality and that is a good comparison. And so it makes the students to view the “mole concept” very positively.

Prior to the SMASSE in-service courses, Mbili taught electrochemistry in which she considered the experiments on the products of electrolysis. Mbili felt that students hated studying Faraday's law of electrolysis. However, after going through SMASSE in-service program, she had seen that it was easy to verify Faraday’s law of electrolysis using improvised apparatus. The improvised apparatus excites students as they really want to see what is happening and like handling the experimental materials. On student participation in lesson activities, Mbili said:

> …And so when you give them this they are already very positive and so they handle the apparatus quite well and they get the results and they are positively motivated. So I think that the topic of the electrochemistry now, is not as difficult as it use to be because we have got the improvised apparatus.

Mbili was able to improvise the Hoffman’s apparatus used in the electrolysis of water. In reference to the Hoffman’s apparatus, she said that “now we have a simple one that we make using the local materials. Yeah, a plastic, drinking water, a container, using strays, using syringes and then…"

On the other hand, Mbili observed that organic chemistry used to be a theoretical topic and used to be the last chemistry topic in the chemistry syllabus in Kenya. By the time Mbili started teaching organic chemistry, the students were already tired and busy preparing for the national examinations. This sometimes left her with only two weeks to cover the broad topic on organic chemistry. Mbili and the students feared handling organic chemicals because there was a belief that they were poisonous. These beliefs made the teaching of organic chemistry theoretical with hardly any hands-on activities. On the effect of beliefs on organic chemistry in implementing teaching/learning activities prior to the SMASSE in-service programs, Mbili said, "at the same time we have a belief that, we used to have a belief that the substances that are handled in the organic chemistry are very poisonous. So we tried to avoid them as much as possible."

However, following the SMASSE in-service courses, Mbili was able to implement a variety of student activities that made the teaching and learning of high school organic chemistry easier. Mbili noted that:

> …after going through SMASSE, we realized that we have a lot of materials around that we can use to teach organic chemistry, like teaching about the alkanes and the alkenes, and the alkynes. By the way like the alkynes I first of all prepared it in SMASSE, otherwise I used to read it in books, calcium carbide and water, and even used to doubt how it would work. But now I can easily prepare ethyne, and then the students can use it in especially in addition reactions. They can do the combustion because they see it, they handle it, they prepare it, they have the alkynes, they work with it they have alkanes, and say the organic chemistry has also become a very interesting topic to the students because of the activities that they do…and we prepare some of the organic compounds like Perspex and you know the students enjoy it. So we used to look at organic chemistry as a topic that is just there and some of these things we see we say ah, these things we just read them but we have never seen them. But now we can prepare most of them and they handle and they feel very happy.

Mbili felt that SMASSE had helped to implement the topic on thermo chemistry with ease. Mbili was able to use improvise apparatus, which are very cheap, very convenient, and using local materials to perform experiments on heats of combustion. For example, she was able to make a simple lamp and then use beer tins to put whatever substance that contains the water. She found the apparatus working very well and cheap because very little alcohol was consumed. By so doing, Mbili was able to provide her students with opportunities to handle the apparatus and use the data to do the calculations on heats of combustion.

Another area that was very interesting to Mbili from the SMASSE in-service program was the Gay Lussac's law. Initially, Mbili used to find teaching Gay Lussac's Law difficult. The difficulty arose from the way one was prepared in pre-service teacher education and students' understanding. On the teaching of this law before the in-service courses, Mbili said:

> Gay Lussac's law, I think even when I was in college, I didn't do anything really with the verification of that law. But because the students find it hard to understand that the route followed in a reaction, the overall heat change, you know, is the same. But you know to explain that to the students seems impossible. That one, you prepare sodium chloride by direct reaction of sodium hydroxide solid and HCl, you get sodium hydroxide, another one you dissolve sodium hydroxide in water and then react the solution with hydrochloric acid. Then when you tell the students that the heat change is the same, you know they do not understand.

However, from SMASSE, Mbili was able to have class experiments to verify Gay Lussac's law and the students were able to observe that it is possible to do them. This made the students understand the concepts involved because they were interesting through use of appropriate student activities.

Changes Mbili made in the implementation of her subsequent chemistry unit lessons. Following the in-service programs, Mbili was able to involve her students in inquiry-based learning. She made her students design and conduct their own investigations. She also involved them on minds-on activities and developed a rapport with her students to enhance their understanding of chemistry concepts. Mbili said that:

> …the Form Three (Grade 11) class that I had, I had taught that class from Form One (grade 9) and then they were in Form three. I had understood and they had understood me. I had really brought them the way that they knew what their heart was and what the teacher's heart was. Like I knew they knew that when I go to class I am not the one who is just going to talk and talk. They knew their parts, there was a discussion, there was the activity of the class experiment, and sometimes I even asked them to design their own experiments and try them out sometimes in the evenings. I tried to ask them plan activities like the role-play, they used to do that.

However, when Mbili had some slow learners in a given topic, she used to have some remedial work with them or ask the laboratory assistant to prepare practical work for them to perform to enhance their understanding. She sometimes asked the students to read some text and then discuss it together.

The SMASSE Project planners: Considerations for future in-service courses. Mbili felt that the SMASSE planners seemed not to have some schools in mind, as their planning appeared to be very ideal. They should consider the schools ability to provide for the materials that are required to effectively implement chemistry lessons. Many rural schools lack the facilities and textbooks for science education. So long as these schools do not have enough money to buy stationery and equip the laboratories, some of the activities that teachers are supposed to implement in schools will never be realized.

The teachers attending in-service courses, together with those who in-service others at the district and cluster level still have the normal workloads in school. The projects' requirement that these teachers have to be involved in all the in-service activities without fail does not augur well with the teachers. The in-service programs have denied many teachers their vacation time and increased their workload with no recognition from the project and their employer.

Mbili would like to see teachers improvising materials during the in-service programs. They should make many improvised materials and be allowed to take them to schools more especially those teachers from schools that cannot afford to buy extra materials for student activities.

Mbili argued that the SMASSE planners should sensitize the Principals so that the in-serviced teachers in their schools are able to implement the ASEI chemistry lesson plans. This will also avoid a situation where a SMASSE-compliant teacher does not find him/herself in a dilemma when implementing student-centered lessons. In her new mixed school, Mbili had observed that:

> …I was planning for an experiment on solubility. So I wanted them to work three per group and yet I was told the other teachers don't do that. They work in groups of six. I said that in a group of six, the students do not handle the apparatus well. They said that when you do that you will have won the probability of many apparatus breaking because when you have many groups many apparatus, I mean boiling tubes, are going to break. Then I said now what do you mean about breaking? Are you sure the boiling tubes are going to break? They said yes, they always break them. And then I said that what is wrong with boiling tubes breaking- in that way you are going to enhance the learning of the students. Then they told me, "Madam" well they will break them but, you know…if they break them and they won't be replaced, we are going to suffer. And they said you see now we can not let the students handle the apparatus because we are afraid if they break there will be no replacement and there will be no practicals.

According to Mbili, to sensitize the principals was likely to change the attitude of those heads, who felt that SMASSE was a waste of time and had become very expensive for the schools. On the idea of SMASSE project being expensive to rural schools, Mbili said:

> …there are some schools where the teaching used to be theoretical, just lecture method, so there was no activity going on at all. So now when you go to the teacher and say please I would like some few papers because I want to make some models, you know to the teacher that is an expense. When you are asking for example this kit I was talking about, you want some apparatus because you want the students do practical in smaller groups, to them they are going to buy more soap, so that is expensive. So that is why they are saying SMASSE has become expensive because they have to spend more money than they have used before.

In-servicing of principals will in turn lead to enhancement of the teaching of high school chemistry. Mbili felt that SMASSE project planners should be able to meet the teachers' expectations in terms of recognition through award of certificates and promotions. The project promised the district educators that they were to be given "trainer of trainers" certificates but after participating in the program for five years, the teachers had nothing to show, while those who went for graduate courses in the local universities were rewarded in terms of grades and salary increments. Mbili noted that:

> …when I joined SMASSE, I had some expectations. Some of the expectations I had may be after going through this "training" I may get some promotion or well I may get some salary increment. But now the way the SMASSE is right now, it looks like such things are not forthcoming. And we were promised that was "trainer of "trainers" certificate and according to when we started SMASSE that certificate was to carry a lot of weight that you would go with it somewhere and may be it will influence. But again, that certificate again up to now is not coming. And the other thing we were told about the certificate that the certificate will be expiring in five years. And so because of such few things, people are becoming negative about SMASSE. In the first place the certificate is expiring and that is the only certificate that is expiring, we have not handled certificates that are expiring but this one is expiring.

The planners should not overwork the district educators, who still have their teaching loads in schools, and yet they are expected to attend their in-service program at the national level in August. They have to in-service other teachers at the district level in April and supervise cluster in-service education in August after their national in-service sessions. This type of organization overstretched the district educators and denied them their annual leave with no compensation. As a district educator, Mbili said:

> …When we went for "training", we were being "trained" in the national in August, in April we would "train" the cluster "trainers", and then in August again we go to "train" in the cluster. And so from all the holidays, April, August and December, of course for us people marking, we were all the time occupied … there are people who are not in SMASSE, and if these people decide to go for some of these upgrading courses. Some of them decided to go for masters degree, others decided to go for diploma courses, like I personally had applied for guidance and counseling diploma course, but because of this SMASSE I gave in and I went to SMASSE. Now after four years, these people have

> finished their courses and look at me I went for this SMASSE, what have I added? Nothing, I am just where I was. No certificate, no salary increment, as I can see it, of course personally, I have become a good teacher and better teacher, alright but you sometimes want to benefit materially and things like that.

In-service teacher education programs should put mechanisms in place to address teachers' expectations. The in-service planners should keep the promises they make to the teachers to avoid dissatisfaction and withdrawal of those in-serviced from the professional development programs. Mbili noted that:

> …of late now, we have very many people who initially were "trained" in SMASSE but have more else leaving the project and they have gone back to school. So like it means now, SMASSE had again started "training especially the district "trainers", very many of them have opted out, they have gone to school. So SMASSE again has to "train" people.

The SMASSE Project planners appeared to take the teachers for granted. They only managed to make the teachers improve on their teaching skills. However, for how long will what they are learning in the in-service programs be sustained in schools? Mbili felt that the planners should incorporate all year round follow up activities to schools so that the in-serviced teachers do not fall back to their old ways of teaching. Teachers need to be properly compensated after undergoing professional development for many years. This was not addressed in the SMASSE project in Kenya. Many teachers were dissatisfied with the way the project was being implemented and administered in the districts.

Tatu

Teaching background. Tatu was prompted to be a chemistry teacher through curiosity. At high school, he used to be fascinated with chemicals in the laboratory and used to wonder why the chemicals had different colors. Tatu developed interest in chemicals made him to want to know more about those chemicals and why most of his schoolmates feared the science and mathematics subjects. Tatu was educated to become a chemistry teacher at the Kenya Science teachers' college for two years. They covered basic chemistry to ensure that all pre-service teachers were at the same level in high school chemistry content. After the basic courses, Tatu was taught additional advanced work and subject methods in chemistry. He did teaching practice for three months before he graduated as a chemistry teacher.

Tatu started teaching in 1984 after graduating with a diploma in science education from the Kenya Science Teachers College. He was first posted to a boys' high school in which he taught until 1989 when he was transferred to another boys' high school in Simba District. He was again transferred to another boys' high school in 2002 within the same district. After two terms in the boys' high school, he was again transferred, on promotion, to head a mixed secondary school within Simba District.

Tatu's chemistry teaching before the SMASSE Project in-service programs. Before Tatu joined the SMASSE in-service programs, he used to hurry to cover the syllabus. He was not minding whether the students were following or not nor did he have a variety of activities to give the students. The range of activities he had was limited. Tatu attributed this to the hurried preparation he went through at college. He felt that they were rushed through the teacher education programs and therefore did not have adequate time to perform all the experiments he had to teach in high school chemistry curriculum. He felt that he was not fully prepared in the assessment and evaluation areas in the pre-service teacher education. In relation to college preparation, Tatu said:

> …I think my teaching was not very much up to date because I feel that we were hurried through the program at the teachers' college. There are some things we didn't do in this area like we didn't try all the experiments we were going to carry out in secondary schools and also other areas like assessment and evaluation was not thoroughly covered so that by the time I finished the course I felt "half-baked".

Tatu noted that the chemistry content is determined by the syllabus in Kenya, in which there was a problem of scope and depth. He did not know much on how deep to go and how wide to cover the content before he joined the in-service program. He used to concentrate mainly on lecture method and gave very little time to experiments and other activities when teaching high school chemistry.

Tatu came to participate in the SMASSE in-service programs because there was an advertisement for district "trainers" in 1999. Through an interview he was recruited as one of the district educators for the SMASSE in-service programs. As a district educator, he was in-serviced at the Kenya Science Teachers College, where the National SMASSE Project offices were located.

The major benefits Tatu received from the In-service Programs. Tatu said that there were certain instructional methods that were not emphasized in his former teacher education institution, but he found them more emphasized in SMASSE in-service programs. He felt that some of the major benefits he received from the SMASSE project in-service programs were his exposure to more activities that he could conduct during his chemistry lessons, how to make student-centered lesson plans and how to manage time during the chemistry sessions. Tatu's student-centered lessons ensured that he was passing maximum benefits to the students in learning and understanding of chemistry concepts.

Tatu felt that SMASSE in-service programs gave him an opportunity to go deeper into those areas that were not well covered in his pre-service teacher education courses at college. He said:

> …exposure to SMASSE activities, I was now aware of how deeper I was to go and how wide I was to cover that content. I had the content of course, in high school we had covered far much content than we were going to teach in the ordinary levels. The only

> problem was on how to pass this content across to the students. The only problem was on how to pass this content across to the students.

Tatu believed that he had no problem with the chemistry subject content. However, he needed to improve on his teaching skills. He felt that the SMASSE project had equipped him with relevant student activities that made him to conduct the chemistry teaching better. In SMASSE, he found that “there were some experiments, such as back titrations, that he learned that he never used before.” These experiments had given him the confidence of conducting more student-oriented practical sessions in the laboratory.

Tatu's designing chemistry unit lessons. Following the in-service programs, Tatu no longer feared lesson planning unlike in the past where he used to think that lesson planning was too involving. Tatu said “I used to feel that lesson planning was tedious. One had to write a lot, but using the SMASSE format I don't have to write a lot.” On the SMASSE lesson plan format, Tatu said:

> The previous format was a bit lengthy and there were very many things involved but the SMASSE format has only about three columns: the step, activity, and lesson notes- These were very easy to fill in, in the format just before a lesson.

The SMASSE lesson plan format had three components: lesson steps, activity part and lesson notes. Tatu found the SMASSE lesson plan format easy to prepare and also very easy to implement.

Changes Tatu made in the design of subsequent chemistry unit lessons. In the designing of subsequent chemistry unit lessons, Tatu was able to make changes. He had learned from the SMASSE in-service courses that one must have a rationale for the lesson. Having a rationale for chemistry lessons, assisted Tatu, as a teacher, and the students to “focus on the content to be covered and also specify their activities in the order they were to be carried out.” Following the in-service courses, Tatu had many student activities to consider during his lesson planning and preparation. About the activities, Tatu said:

> After SMASSE, I have learned a range of activities like we can have role play, some kind of drama, crosswords, word burrs and so on. The ranges of activities I choose depend on the content to be covered. The range of these activities makes the students to enjoy the lesson and to grasp the content better.

Tatu incorporated lesson evaluation during his planning. The feedback from lesson evaluation assisted Tatu to improve on his subsequent lesson plans. Tatu observed:

> …each time I present a lesson, I have to evaluate whether I achieved my objectives and when I find I have not achieved the objectives, then I have to introduce more activities or have different activities which can assist me to achieve the objectives of the lesson.

Tatu assessed his lessons by getting feedback from his students or colleagues. He used question answer techniques to evaluate his students understanding of the concepts he was teaching or by asking the students to write comments about what they thought they had enjoyed learning and the areas they would like their teacher to address in subsequent lessons. On lesson assessment and evaluation, Tatu said:

> I ask the students how much they have benefited from the lesson or what they have actually learned from the lesson and then assess their responses and then I am able to know whether I achieved my objectives or not. I also some times invite my colleague teachers to attend a lesson and assess me. Some times I give the students a piece of paper to comment about the lesson.

The students' comments were of great help to Tatu in planning subsequent chemistry lessons. Through student comments, Tatu was able to know the strengths and weakness of his chemistry unit lessons. On students' feedback, Tatu said "those comments assist me to identify areas of weakness so that I can improve on them or also the strengths of the lesson so that I can use that kind of approach more often."

SMASSE's influence on Tatu's implementation of chemistry unit lessons. Tatu believed that the area of the periodic table was the core of all the chemistry. He felt that the SMASSE in-service programs had assisted him to know that he had to emphasis certain aspects like bringing out patterns from the periodic table. Considering patterns in the periodic table, Tatu believed that "students are able to grasp the content about the periodic table better." The SMASSE in-service programs had also enabled Tatu to know that he must also "bring out trends across the periods or down the groups to assist the students in grasping the chemistry." Tatu believed that the "mole concept" was an area that many secondary school students found very difficult to study. The word "mole concept" itself was scary to the students. Tatu observed that:

> …Like the mole as a number it is a big number, six point zero two times ten to the power of twenty three ($6.02x\ 10^{23}$). Some students are not able to imagine such a large number. They are used to small numbers that they are able to count but now we have to tell them that since the atom is so small, you have to take so many atoms in order to come up with a reasonable quantity of matter.

However, the SMASSE in-service courses had assisted him greatly in simplifying the concepts and using models to teach the "mole concept". Tatu noted:

> So from SMASSE, I learned that there are models we can use and also there are examples we can give like we say a pair is two, a dozen is twelve and then we extend like that and finally say that that number, $6.02x\ 10^{23}$, is a "mole". So when we start from known to unknown, the students are able to get what the "mole" is.

Tatu's new approach to teaching helped students to understand the "mole concept" with ease. Tatu had improved teaching the "mole concept" because of the SMASSE in-service courses that he had taken. The programs had exposed him to more experiments that students were to perform in school. Tatu said, "...but from what we covered in SMASSE, I have been able to simplify the "mole concept". I have especially known which experiments to carry out to explain better aspects about the 'mole' concept''.

In the area of electrochemistry, which mainly involves the electricity, Tatu felt that many students found it abstract. However, from the activities he covered in SMASSE, he was able "to carry out experiments to show students how ions are moving." As Tatu put it:

> Ions are some of the difficult particles for the students to visualize. But from SMASSE we have such experiments like passing electricity through potassium permanganate solution on some microscope slides. Here we suspend the solution on a filter paper placed on some microscope slide, then, we pass electricity through the solution using crocodile clips. So one clip will be positively charged, the other one will be negatively charged. Since the permanganate ions are purple, they are colored and they are negative they will be attracted to the positive terminal. And since potassium ions are colorless and they are positive, there will be attraction to the negative terminal. So after carrying out the experiment and explaining, the students seeing the purple on one side, colorless on the other side, they are able now to see that ions must have moved.

In the area of organic chemistry, Tatu had limited student experiments before he joined the SMASSE Project because he had no test tube experiments for the students to carry out. However, the SMASSE in-service programs had exposed him to more experiments in organic chemistry, which were simple and required use of locally available materials. Tatu involved his students in a variety of activities and doing simple organic experiments when teaching the organic chemistry content. Tatu's new way of teaching the organic chemistry had great impact on students' grasp of the concepts involved.

SMASSE Project in-service programs had assisted Tatu to improve on his teaching in other topic areas that were not covered in the program. Tatu said:

> There are areas like thermo chemistry, radioactivity and so on that the SMASSE as a teacher you need to teach better. In the area of thermo chemistry, before SMASSE, I didn't know which experiments I would carry out to demonstrate Hess' law but I learned one experiment in SMASSE and actually these experiments are very simple and the chemicals that we can use to carry them out are available.

When Tatu was asked to explain the type of experiments he would conduct to demonstrate Hess's law, he said:

> They are experiments like neutralization because Hess' law states that the heat change in a chemical reaction will always be the same in spite of the route you have taken to move from the reactants to the products. So, one can choose suitable reactions, like say, reacting sodium hydroxide with hydrochloric acid. You can either use, consider the solid sodium hydroxide reacting with hydrochloric acid or sodium hydroxide solution reacting with hydrochloric acid. And by combining a set of reactions like first the sodium hydroxide solid has to dissolve to form a solution, there is some heat change there. Then after it has dissolved, then it reacts with hydrochloric acid, there is some heat change by neutralization. By combining these reactions and designing suitable experiments you able to demonstrate the lesson.

Tatu further observed that "radioactivity is an area that most teachers fear to teach." Since it was not possible to conduct experiments on radioactivity in the school laboratory, the SMASSE in-service programs had assisted Tatu to be able to plan relevant activities when teaching radioactivity. About the many teachers' fear of teaching radioactivity and SMASSE in-service programs' interventions, he said:

> They feel that if they handle those chemicals that are radioactive, they can end up getting cancer. But from SMASSE, I learned that instead of carrying out those experiments, you can show some video or some film and when students watch they are able to grasp the concepts rather than carrying out the actual experiments.

To compensate for the non availability of school laboratory experiments on radioactivity, Tatu suggested that students can be involved in viewing a video or film on radioactivity reactions.

Changes Tatu made in the implementation of his subsequent chemistry unit lessons. Among the changes that Tatu made in his lessons were that he infused more activities in his lesson plans and as much as possible made the lessons student-centered unlike before when they used to be teacher-centered. In this way, Tatu involved students more in his lessons. The students were able to perform activities that assisted them to learn the chemistry unit content better. Tatu assessed his students' understanding of the concepts he was teaching to assist him in planning and implementing activities that facilitated their learning. On the changes Tatu made when planning and implementing student activities, he said:

> …First I have to assess to find out from the students how much they know about that content I am going to cover. Then now depending on the feedback I get, then I can even change the activities I had to suit the situation.

When asked on how he implemented the changes he made, Tatu said:

> …Let's say you had planned something like a demonstration and then in my interaction with my students I find that a class experiment would be more suitable, then, I have to change and give that as a class experiment. Or alternatively you may find that in my planning I had large groups of students to perform an experiments but interacting with the students I find that smaller groups would be better, then, I go ahead and do that.

Tatu was able to have diagnostic assessment during his chemistry unit lessons and used the feedback to make decisions, which he had to act upon immediately.

The SMASSE Project planners: Considerations for future in-service courses. According to Tatu, the SMASSE project planners "must find a way of producing more resources, more teaching and learning resources to support the teacher." Tatu felt that the in-servicing of teachers alone was not enough. The planners ought to ensure that there was provision of science textbooks that incorporate the SMASSE teaching/learning approaches and relevant student activities in the rural areas of Kenya. The in-service program activities have to be planned and implemented in a manner manageable by teachers. The teachers should not feel that they are being rushed through a broad-based program within a few days. Instead, the in-service programs should be provided throughout the year and let teachers choose when to attend them. On the issue of textbooks and time management during the in-service program activities, Tatu said:

> …there must be textbooks in the market that have that SMASSE approach and also materials for experiments, there must be some experiments that are designed along SMASSE lines. Also during the in-service, the activities that are carried out there should move at a reasonable pace. There should not be a crash program that will make the participants not to enjoy the in-service. The activities should move at a normal pace so that the participants can enjoy the activities.

The planners need to organize the in-service activities in a way that motivates the teachers. The teachers ought to see the benefits of an in-service program in terms of teaching skills and recognition of the in-serviced teachers. Tatu observed that:

> …a way should be found to motivate the participants. Of course we know the in-service is for their benefit but there should be conscious effort by the people implementing the project to motivate the participants…teachers who get in-serviced can see direct benefits from an in-service like getting promotion, having salary increment or something like that. And also there should be more recreation during the in-service so that the participants feel normal and can learn more during the in-service.

Tatu felt that the SMASSE in-service planners should provide time for the participants to relax after the day's sessions in residential in-service programs. There should be provision of recreational activities in residential in-service programs. Tatu reacting to the rigorous SMASSE in-service activities he was involved in, he said:

> There should be time for let's say participating in games, both indoor and outdoor, and also those who enjoy dances should have opportunity to do that so that an in-service is like a normal activity not just a crash program.

These recreational activities should be provided during an "in-service that may last for more than a week'. Tatu felt that "people need to be relaxed as they undergo the in-service" that is residential. On the other hand, Tatu observed that the in-service planners should note "that it is not only chemistry that will make students better, but there are also other subjects like the languages and the humanities that have to be catered for." To strengthen the teaching and learning of chemistry, "there should be some in-service for these other subjects."

Nne

Teaching background. Nne started teaching on July 15, 1994. At that moment she had completed from Kenyatta University, and was posted at Boima mixed secondary school to teach biology and chemistry. At Boima she taught biology and chemistry. After working at this school for nine years she was transferred to Nyaima Girl's high school where she was mainly teaching chemistry. Nne had never thought of becoming a teacher but had great interest in the sciences and looked forward towards succeeding in this subject area that was dominated by males. As she put it:

> I won't say that I wanted to become a chemistry teacher because I felt right from within me that I had to venture in the world of science. I could see right from home where the society was like the humanities are meant for ladies and the sciences are meant for men. So right from the time I was in Form one, I started to work very hard in the sciences having scored a clean "A" in my CPE (referring to the certificate of primary education examinations that were done at the end of grade seven in Kenya).

In school, Nne worked very hard in her science classes despite here fathers liking for the art-oriented careers. She had benefited greatly from her high school principal’s advice on her school work. Her dad was a police officer in the crime’s department who retired in 2003.

Nne commented:

> Then, when I reached Form three I went to the science stream but I had I conflict between me and my father and the school administration, where my father felt I should go to the humanities class. But with the guidance of the Principal his mind were diverted but he assured me that if I failed in Form four, I do not qualify to be his child. But I worked very hard. And surprisingly when the results were out, I had credit 3 in chemistry and credit 3 in biology which enabled me to handle chemistry, biology and geography in high school, where he had again come to the principal and told her that he wanted me to change and do C.R.E (Christian religious education), geography and economics by the simplest fact that my sister had done the same subjects and she had passed and she had gone to university. We had again a crisis for a time. Again the principal instructed him to leave me alone but he had declared again that if I fail I do not go back to his home. But after I did my "A" levels, I passed very well. I had three principals and one subsidiary, then, I joined the university.

At Kenyatta University, Nne pursued a bachelor of education in science degree. They were taught science content beyond their advanced level they had covered while in high school. She did more units that covered research work but not the content she was going to teach in the high school syllabus: She said:

> …a university is a higher institution of learning for research. So personally I want to say that the preparation given to me to come and teach chemistry at secondary school was not very adequate because what I was taught in college, I have never taught it in class …I

> was not prepared for the secondary school syllabus but instead the units I learned were meant to be for research at a higher institution of learning.

Nne commented, further, that “at the university, I did botany and zoology, and then chemistry plus education units.” It is worth noting that Nne’s sentiments are not far fetched because at the university one did botany and zoology as two science subjects. For those being prepared to become professional teachers, they had to have two teaching subjects. Those who had done botany and zoology were counted as having done biology and so had to do a second teaching subject. These group of students had to attend a subject methods course in the second subject selected, of which they do not do content at the university level. This was the case for Nne’s preparation as a chemistry teacher at the university.

Reasons for joining the SMASSE In-service Education Program. Nne had known about the in-service program from the circulars sent to schools in which they were to apply for consideration as district in-service educators to be educated at SMASSE’s national in-service education center in Nairobi. However, she was late in applying. She was invited to attend the district biology in-service education in Chui district. With the assistance of the chairman of the head teachers’ association in the district, she was able to change to chemistry education.

Nne’s chemistry teaching before the SMASSE Project. Nne felt that she had no problem with the chemistry content taught in high school. She had enough content knowledge to handle any area of high school chemistry. Her school had inadequate resources for teaching chemistry and this made her to cover the content theoretically and occasionally did teacher demonstration experiments when it was possible to do so. As Nne put it:

> …in this case I want to give the way I used to teach chemistry while I was in my former school. That was before SMASSE. With content, personally I could say I do not have a problem with it. I know every other aspect of chemistry, in terms of content. But when it comes to instructional methods, before SMASSE and because of the school where I used to be, which lacked facilities, around 70 per cent of the work was being covered

> theoretically. And it is a small percentage where we could have practicals and indeed if they were practicals, they were a teacher demonstration practical.

In her theory lessons, she used to go to class and introduce a lesson, teach using lecture method. In this teaching I would try to explain to the learners what they were expected to know. She also explained the practical aspects to them although they were not able to observe or perform the experiments. As she put it, this type of teaching, "I can say it used to be very very difficult." In the teacher demonstration lessons, Nne used to have her students assemble around the teachers table in front of the class as she performed the experiments. The students' role during these teacher demonstrations was to observe the experiments and write down the observation which they discussed thereafter. Nne said:

> …demonstration I could have the apparatus at the front bench. I assemble the students around that bench and carry out that practical while explaining to the learners what I am doing and the learners could make observations. I want to say that during those teacher demonstrations the learners could be excited because for one they could see an experiment done.

After the learners had the observations, Nne said "we could discuss the observations and put the points down." Following the teacher demonstrations, "in the next class students could be quite in interested state. They could be ready to learn. But unfortunately you could find that that next class what you are supposed to use in terms of reagents and apparatus is not available." She had to cover many of her lessons theoretically. This is where the SMASSE Project in-service program came in handy to Nne who had to enhance her instructional skills.

The major benefits Nne received from the SMASSE Project In-service Program. One of the major benefits Nne received from the SMASSE in-service education program was the improvisation skills. Being in a district "harambee" school that had inadequate provision of resources for effective chemistry teaching, Nne needed appropriate instructional skills to be able to handle chemistry sessions in such conditions. The in-service education programs had made

Nne to have positive attitude towards the teaching of chemistry in schools with limited resources to teach chemistry. As she put it:

> Now from SMASSE, I can say one thing mainly I benefited. Most was that it tried to handle or look into the secondary curriculum. That is what we already handled. So kind of they enriched me with what I could do in cases I am not able to get the apparatus I need or reagents because after the in-service I was able to go round other schools and borrow. I was able to improvise few apparatus for use. And my attitude became even more positive because initially if I could collide with the head teacher because I want a reagent or a chemical and he is not able to provide I could go to class but with a mixed mind. But it made me become a positive person all round.

During the in-service programs, Nne learned how to improvise various items she could use to teach chemistry in her rural school. She commented:

> …From the SMASSE group, I learned on how we can make a suction pump which could [hinder] me to burn hydrogen in the lab. Then I also learned about making a gas generator, where I am just using these quencher bottles and the drinking straws. I learned that I don't have to have a conical flask before a titration can take place, I can use glasses. You do not have to heat substances in evaporating dishes, on crucibles; I can use bottle tops which are available all over. I do no have to wait that I do not have spatula, I can use drinking straws the ones you have made. I do not need to buy filter papers; I can use a piece of cloth, tissue or cotton wool, which could be readily available, such kind of examples.

Nne's attitude towards the learners also changed as a result of the in-service programs. District "harambee" schools had students whose score in the national primary education examinations were low. Many teachers looked at this group of students as low achievers in academics without finding out whether their score was low because they were in disadvantaged primary schools and the students' socio-economic status in rural areas. On her change of attitude towards the learners, Nne said:

> …For one my attitude towards the learners changed because I used to feel that since they were low achievers and sometimes I could teach myself. Ask myself a question and answer myself. They are there, you teach them, any question nobody telling there is a question or you ask a question, nobody answers and I answer for them. It used to kill, you know, the morale I am supposed to have in teaching. But after SMASSE and our in-servicing attitude, I was told that I have to accept these children like they were my own

> children. I was supposed to have them at heart. So despite their level of understanding, I took them to my heart and I really tried to be working with them.

Prior to the in-service programs, Nne hardly used to involve her students in the teacher demonstrations other than making observations on what she was doing in the experiment. Following the in-service courses she was able to involve the students more in the teacher demonstrations. The students could assist in performing the experiments and changed them in subsequent sessions. This ensured that all the students were given opportunities to participate in the teacher demonstration experiments. Nne said:

> …What I did not know is that may be in a teacher demonstration, the learners are supposed to be involved. That is one thing I learned. The other thing is on improvisation, which I didn't know and that issue of having students at heart. I used to be mainly sure that my work is especially good.

Nne continued to elaborate on how she involved her students not in the teacher demonstrations but in class demonstrations, in which she added:

> Like if I have to have a teacher demonstration, I can have one student arranging the apparatus another assembling the apparatus, I will instruct one may be put this chemical here, another one add this chemical, and they make observations. From the observations, they have to explain them and come up with points to help us in that learning. Until… in the work plans I made, I did not talk of a teacher demonstration, and I talk of class demonstration.

Students' involvements in class demonstrations minimized teacher-centered demonstrations which had the tendency of having students as passive observers and just there to answer the teachers' questions.

SMASSE's influence in Nne's designing the chemistry unit lessons. Before Nne underwent the in-service program, she used to prepare her lesson plans in which she wrote the topic, objectives, references and what she had to teach under lesson development. She argued that at that time she never used to include information on the observations the students were to make during her lesson development. Following the in-service education sessions, she had improved on the way she prepared her lesson plans. Although the SMASSE lesson plan format required more time to prepare, she felt that it was teacher friendly and advantageous because it included lesson notes. As Nne put it:

> …When I look at the lesson plans we used to make from university, it wasn't that detailed. You could just write the topics, the reference and the objectives, and then the lesson development. You just indicate what you are going to teach not even the observation like if it was an experiment I could say students should light a Bunsen burner. But once we come to the SMASSE work plan, I can say they are good and well-detailed work plans because in that work plan I have the lesson notes. Much as it takes time to prepare, once prepared it is teacher friendly.

Nne used her lesson evaluations' feedback to improve on her subsequent lessons. She sometimes found herself not covering all the objectives she had planned for her lesson because of time constraints or the chemicals she anticipated to use were not available. On the changes she made in her subsequent lesson plans, Nne said:

> …First I look at the lesson plan I had today to guide me make a lesson plan for tomorrow. May be for one reason or another, you may be there is an objective I did not achieve, so I have to include it in this section. That is the lesson plan I am going to use tomorrow. And in cases where I did not achieve those objectives it is either I ran short of time or the apparatus or reagents were not available. So in a way I made changes during this lesson to suit for the following lesson.

Running short of time to cover the planned lessons was not as a result of inadequate planning or over-planning but it was because of unforeseen circumstances emanating from the school administration. On running short of time to cover her prepared lessons, she commented:

> …For instance if I have a class immediately after assembly in the morning, such classes are normally affected because we have announcements at assembly, we are raising the flag, we are praying. There are times when I have planned for eighty minutes lesson I end up teaching it in sixty minutes.

However, whenever she prepared her lessons she had to identify the materials required for a successful lesson implementation. She had also to know the level of her students. This ensured that she was able to cater for individual differences in her chemistry classes. On how she prepared for her lessons, Nne said:

> …When I am making a lesson plan there are things, which have to identify with me. For instance, I must know the chemicals if they are there, the reagents if there are there, and also I must know the level of the learners because it is needless for me to lesson plan while the level of the learners is low but if it is high it means I have to lesson plan more. And if they are average, I also I have to lesson plan averagely.

Having prior lesson planning with students and the required teaching and learning materials in mind enhances students understanding of chemical concepts during lesson implementation. This is where the SMASSE in-service education programs had had an impact on Nne in improving her lesson planning and teaching skills.

Implementing chemistry unit lessons on the Periodic Table. Following the in-service education courses, Nne was able to have a practical approach in her teaching of the periodic table. She was also able to make models of substances using improvised materials. In her words, Nne said:

> …in the periodic table the SMASSE project has made it possible for me and my learners that we are following a right trend. For instance, I could cover the energy levels, shells, electrons theoretically but now I am able to use structures. I have wires, which are bent round and then I am using the "Plastocene" to stick them together and I am using bottle tops to represent electrons. I am able to make up to four energy levels that are up to the level of calcium. Some of them are here in the lab and students are able to observe them and they are able to understand what I mean by the nucleus, so we have protons and neutrons and around how electrons go round. …What the maximum number of electrons needed by a particular energy level. At least that one it made possible that they are able to see.

Use of the improvised materials ensured that abstract knowledge was simplified for the benefit of students. Nne used materials such as wires; “Plastocene”, sticks or bottle tops to demonstrate to the students the arrangement of electrons in the energy levels of an atom. This had assisted her students to follow chemical concepts involving the periodic table with ease.

Implementing chemistry unit lessons on Electrochemistry. In electrochemistry, Nne was able to improvise apparatus that she did not have in her school. The improvised apparatus made it possible for her to teach experimental work in electrochemistry, areas she used to avoid doing before the in-service education program. In particular, she was able to improvise the Hoffman's apparatus which her school could not afford to buy. The Hoffman's apparatus are used to perform electrolysis experiments for solutions such as dilute sulfuric acid. She improvised the Hoffman's apparatus using plastic containers, carbon electrodes from used dry batteries, calibrated syringes and straws. On how the in-service education courses had assisted her in planning and implementing better electrochemistry lessons, Nne put it:

> …Then on electrochemistry, I want to say that it has been made possible because like cases where we are learning about electrolyzing dilute sulfuric acid. There we talk of Hoffman's apparatus, which are expensive for an institution like this one to afford. What we do, we have the improvised one, where I have used the quencher bottles, I have batteries then I have the electrodes. Of course the electrodes are extracted from cells, which are battery cells, and then I have syringes which are connected at the top, which are [connected] at the top by straws. And once I use those straws kind of I am packing in and that gas, which displaces the water, so with that I am able to teach electrochemistry in that section, where I used to teach theoretically.

Enhanced teaching and improvisation skills had made Nne able to handle electrochemistry areas with ease, areas she used to cover theoretically before the in-service courses.

Implementing chemistry unit lessons on Organic Chemistry. When teaching organic compounds' structures, Nne used to draw the structures on the chalk board. The carbon-hydrogen bonds that are supposed to be at 109^0 apart were shown to be at 90^0. This kind of representation was likely to lead to misconceptions as to how the carbon-hydrogen bonds are arranged in an organic compound. However, through the in-service education programs Nne was able to make models of the organic structures. Through the improvised models, the students were able to visualize the atom arrangements in an organic compound. This approach reinforced the students understanding of the organic chemistry, which many students were finding difficult to learn. On her new approach to teaching organic chemistry following the in-service education programs, Nne said:

> …When it comes to organic chemistry, where I could teach the students that the hydrogen atoms to carbon are at a plane. You know I could put it like it is a cross; I have one up, across, across and down. Now that one is really changed because I could just tell them the structure is like this but otherwise they assume the angles of a tetrahedron, which is a hundred and nine degrees. I am able to show it practically because now I can use "Plastocene" with tooth pick and to display those angles that this is how it is.

Nne was also able to demonstrate double and triple bonds in organic compounds using her improvised materials in which she used toothpicks and “Plastocene”. The toothpicks represented bonds while she made atoms of various substances using different colors of “Plastocene”. This was in line with the use of locally available materials to teach chemical concepts. On this practical approach to teaching organic compounds using locally available materials, Nne added:

> …And then after I move from alkanes to alkenes, I am able to show two toothpicks to show the double bonds. [And moving] to alkynes, [I use] three toothpicks to show the presence of the triple bond. So there is that practical aspect.

The use of locally available materials to teach organic chemistry was one way of having the students make sense of the chemistry content they come across in school with that they experience outside school. It also showed that it was possible to have a practical approach in teaching organic chemistry without having to perform class experiments.

Implementing chemistry unit lessons on the “mole concept”. Nne felt that students used to get confused as to how a “Mole” could be found in chemistry. Following the in-service programs, she was able to handle the “mole concept” area better than the way she used to cover it before. She had improved on her topic introduction, in which weighed a variety of substances against a certain mass. The students were able to see how different number of items that were similar in size and mass balanced the reference mass that was kept constant throughout the activity. Nne said:

> …in the "mole concept" I am also able to teach it well to my learners because students get confused we do not understand how a mole can be found in chemistry. But I have come to explain to them that it is used as a unit and the way I introduce the topic by weighing, you know, various, let's say a variety of substances or items against a particular number of mass. And from there we are able to come up with that however how much it is, as long as you keep this amount going and the other one, they are able to occupy may be one mole of the, to form one mole of that particular substance.

The knowledge gained from the in-service programs was made use of in other topic areas that were not covered during the in-service sessions but were being taught in school by Nne. Prior to the in-service sessions, Nne feared preparing some gases which were dangerous to prepare in the school laboratory. Perhaps the fear to prepare these gases and the dangers they posed might have been because of the inadequate preparation she might have undergone during her pre-service teacher education on safety in the chemistry laboratories. In covering chlorine and its compounds and sulfur and its compounds, Nne said:

> …I used to fear preparing chlorine and sulfur dioxide because in the past when I was preparing chlorine it affected me in one way or the other because I thought it just I have to prepare it to the learners. And I was doing outside but the direction of wind changed all of a sudden. I remember I coughed for some time and I went to hospital and I had medication, although I felt the effect until may be for some time.

Unlike before the in-service education program, Nne was able to prepare gases such as chlorine and sulfur dioxide on small scale based on the acquired in-service education knowledge and improvisation skills. As Nne put it:

> …but now, through SMASSE, I am able to prepare chlorine on a small scale by use of chips instead of conc. Hydrochloric acid and potassium permanganate, so I am using chips instead of that. And then unfortunately they are in the school where I am, that is the place for a fume chamber, so I can also prepare it. Sulfur dioxide, I can prepare it on a small scale where I have just a boiling tube as the reaction vessel and direct it, maybe to carry a flask, and to other substance where I want to blow it through it.

Having appropriate improvisation skills and being able to prepare the gases on a small scale, had improved Nne's chemistry teaching sessions from being theoretical to being practical-oriented sessions. The practical oriented chemistry classes were likely to increase the students' interest, curiosity and participation in learning school chemistry. This in turn might lead to more students qualifying for chemistry oriented careers in future.

On the changes that Nne made when teaching chemistry she said "I won't say that there are no changes" but her classes sessions went on normally. About her chemistry lessons, she added that "it just goes as normal. As long as I have achieved the objectives of that particular lesson, the following lesson just goes on well." From Nne's observed class sessions, she conducted her classes with ease and professionally. She was a superior teacher in class.

The SMASSE Project planners: Issues for consideration. Nne felt the SMASSE Project had stringent conditions for teachers. An in-service program ought to be a collaborative effort between the in-service providers and those being in-serviced. The district in-service educators had their full school workloads and yet they were supposed to conduct the district in-service programs as a full time job. These SMASSE project planners' arrangements for the district in-service educators were not auguring well with Nne who said:

> …about this SMASSE, there are a few things they need to know for one their conditions are too much. They expect so much from the district "trainers", which will not be achieved in the near future. The reason being that this district "trainer" has a full work load to teach back in the classroom and at the same time they need her to be in the [team] or her to be a researcher on that process.

For the in-service programs to be sustained in relation to human capacity building, Nne was of the opinion that ministry of education officials ought to plan well. The district in-service educators should be relieved from some of the work they do in school so that they have more time to plan and implement the district in-service programs for chemistry teachers. On what

SMASSE planners ought to do, she said, “so one thing they are supposed to do they should talk to the Ministry of Education, so that district ‘trainers’ lessons should be [reduced], the workload should be made low.”

According to Nne, some of the conditions put forward by the national SMASSE in-service center were unrealistic. There seemed to be a miscommunication on how the district in-service educators were supposed to be awarded certificates recognizing their role in promoting in-service teacher education in their districts. One of the conditions cited by Nne seemed tough to many of them who were not ready to pledge their faith to anybody else except their God. She observed:

> The other condition is the conditions of awarding the district “trainers”' certificate, they are a bit tough because not all of us who can go pledging to them. They think you…, they say that…like there is one they say you must be very faithful to the project and work as per by their needs. That is one objective, which I know many can not achieve because there are those who believe you don't go pledging your faith to somebody else.

As a district in-service educator, Nne was not satisfied with the personnel who were recruited to in-service them at the national level. Many were young and recruited from non-SMASSE districts. Many of the newly recruited national in-service educators appeared professionally inferior to the district educators who were more experienced and had undertaken the national in-service courses for some time before the new recruits joined the project. This mismatch of the in-service education personnel at the various levels of the project was a case that future in-service planners ought to address to avoid dissatisfaction from those being in-serviced. The situation was made worse by the national SMASSE in-service education center’s non-consistency as to who should be joining the project as a national in-service educator. Nne said:

> The other thing they should take into consideration who becomes a national “trainer” because like if there was need to add national “trainers” like they did last year, they should have considered people who “trained at district level, who “trained at national level who are district “trainers”. But they went to non-SMASSE districts and they were

> carrying out interviews from there and when they were carrying out the interviews they had specified "district 'trainers' must not apply." That was one way they killed the district "trainers'" morale. .. They should also consider who becomes a national "trainer" depending on the level of learning. That does not mean that if somebody is a diploma holder is useless but they should at least consider the level of that particular person.

The education of the district in-service educators outside the country was not done equitably for all the pilot districts. Some districts were treated unfairly since none of the sixteen districts in-service educators were taken for further education as was the case for other districts. This was the case for Simba district whose district in-service educators were not considered for any education outside the country. As Nne put it:

> …about the issue of taking the "trainers" outside the country, they are not giving those chances equitably. There is something else, which is being done. I don't know in tribal lines or on understanding where you find others going like from one center we had one teacher going to Japan, from the same center we have another teacher going to Philippines. That is being unfair, they should also motivate others.

Nne felt that there was need for the district in-service educators to pursue further studies in science education. She said that one "can go in for masters if you do not have it. Those who already have masters can go in for Ph.D." and that "It is not a must [for them to go and study abroad]. That is why I have talked about local universities." Further education for the district in-service educators, therefore, does not need to be undertaken outside the country but they can be sponsored to study in the local public universities. On the possibility that not all district education educators can be taken abroad for further studies, Nne said:

> …since it may not be possible, I have a feeling that somebody can even be sponsored to go to a local university here within the country. There are so many may be projects going on. You can even be attached to some of the JICA sponsored [projects] in the country where you can go and do one or two things. It doesn't necessarily mean that you just have to go abroad since we are so many.

Nne felt that their participation in the SMASSE Project in-service teacher education programs, as district in-service educators had not been rewarded. The project's objectives were being realized at the district level where the stakeholders were stationed. It was the efforts of the district in-service educators that the project succeeded in in-servicing teachers. However, the promotions and monetary gain was only left for those at the national in-service education center. In Nne's opinion, the SMASSE administrators ought to have recognized the district in-service educators' role in sustaining the in-service teacher education programs at the district level by either promoting them or providing allowance for the services they provided. This was not the case for the SMASSE project. The district in-service educators sacrificed themselves more in implementing the SMASSE Project in-service program and yet they had nothing in return other than improving on their teaching and improvisation skills. Nne said:

> The other issue is about the position of this district "trainer" because SMASSE started way back in 1998. Some of us started attending it in 1999 for a period of five years. Other than the expertise I have gained in the teaching of this chemistry, monetary-wise or in terms of job group, I have not gained anything because we have our colleagues who went for masters, others are even pursuing doctorate while I am still in SMASSE and I have not been [rewarded].

The national in-service office seemed to be changing its position on the district in-service educators' role and recognition as successful implementers of the project's objectives. It appeared as if the district in-service educators were being used to achieve the objectives of those who came up with the project. Nobody cared for their upward mobility in the profession rank-wise or in terms of allowance to compensate for the enormous amounts of time they spent on SMASSE project matters. This was one way that in-service education programs were likely to fail in Kenya because there were no proper mechanisms put in place to sustain the project financially and in human capacity building. One does not expect the in-service educators to be satisfied if they gain no recognition from their employer or the project sponsors. As Nne put it:

> Initially there was an objective for SMASSE that once you complete, you are awarded a job group a head but that job group has not been seen yet. And now they have changed they want to say the conditions we are supposed to meet. Initially they said there were

> three cycles of INSET (in-service education center) but they went up to four and now I hear we being told from the national office that district "trainers" should think and rethink and come up with the fifth cycle at their district.

Inconsistencies in the professional development of teachers by the project planners were likely to cause confusion among the teachers. Dissatisfied teachers are likely not to see the benefits of an in-service programs however much one might try to convince them. Teachers ought to see the benefits of an in-service program in terms of their professional growth. It is not enough to have teachers undergo an in-service program and yet when it comes to promotions their participation in such programs does not count. Non-in-service teacher education participants were promoted to become seniors of those who were involved in promoting chemistry education through in-service education. Nne, as a district in-service educator, was dissatisfied because to her the SMASSE project planners were not taking their needs into consideration.

The teaching of secondary school chemistry is influenced by what students do in other subjects. The students need language and mathematical background for them to follow chemical concepts with ease. In this regard, Nne felt that "not only science and mathematics teachers need an in-service education." She observed:

> All teachers must receive an in-service because like when we look at our fellow counterparts in the humanities, in the languages, the last time they had lessons is when they were in college. Which means where they were is still where they are. And when they see science people, math people making changes, they receive them with a lot of ridicule. They imagine these ones are doing their own things. So I believe and my feeling is that it is very, very necessary that every teacher receives an in-service.

However in Kenya, ones teaching may be assessed from the results of that person's candidates he/she prepared for the Kenya National Examinations Council. Depending on the level of provision of facilities in a school, Kenya has national schools, provincial schools, and district schools. Many of the students whose science capability needed to be enhanced are found in the district schools. District secondary school students had low marks at the primary education national examinations. They have the poorest provision of resources to teach science. While improvisation of apparatus can help this group of students learn chemistry, the national examinations do not set questions based on improvised materials. The SMASSE in-service planners have to work hand in hand with the examinations council so that students answer a certain number of examination questions based on their local environments. On the assessment of a successful chemistry teacher, Nne argued:

> I want to say that one is not fair because a teacher in a national school and in a provincial school, them they will qualify in many things compared to those teachers found in the category of "harambee" (district) schools. We are not going to measure the capability of a teacher against the students. Note the problems of this teacher to be found in that local "harambee" school. It is only that she is a victim. She has been sent there by the government. May be what they need to consider is who has done more work because if we have students whose cut off marks was 430 (out of a maximum of 500) going to “Starehe” (one of the national schools) and all of them pass with the least having a B minus, there are students going to a local “harambee” school with as low as 100 marks but in a way this teacher teaches these students until he or she achieves a B plus. I commend the teacher in a local “harambee” school compared to the teacher at “Starehe” because what happens in these national schools and some provincial schools, those learners are very bright and they revise on their own.

According to Nne, students in district schools had no science textbooks and being in rural schools they had problems with the English language. Teachers in these schools thoroughly prepared the notes they were to give to their students to supplement the inadequate provision of chemistry textbooks. Almost all students in district schools are day scholars and do not have conducive learning environments for studying at home after school. So the system of rewarding teachers in Kenya based on their students’ results in the national examinations has not been fair to teachers in district rural secondary schools. As Nne put it:

> But a teacher in a local “harambee” school, to begin with those students do not have textbooks, they don't even understand English, you have to start off by teaching the English, how even to write their names. As if that is not enough, they do not read, they rely on teachers' notes who must read widely, prepare for them notes from various

> textbooks, which textbooks the school doesn't even have. You have to borrow or buy your own. So the ability of the learners should not be made against the ability of the teacher.

Those involved in the promotion of the science education in schools have to consider the teaching environments teachers were exposed to in order for them to have a fair assessment of the impact of the in-service education on the achievement of students.

Tano

Teaching Background. Tano started teaching in 1989 and at that time she was teaching biology, and chemistry at [Kionyo girls' secondary school] in eastern province. At that time she was straight from college and she found "teaching quite interesting and motivating more so when you teach the students and the students do well." Her students did well and were interested in their studies. She said, at "that time I was very eager and…I used to see that the students perform well."

Tano joined her present boys' school in second term, 1993, after she got married and then was transferred to the school. The boys' school had a different social setting but she found "science very easy to teach to the boys, although the approach to teach boys and girls are slightly different." When comparing teaching in a boys' and girls' school, she had realized that "sometimes with girls you really have to push them to do something. But once they get it, they get it but with boys, boys are more eager to learn than girls." At the school, Tano had been teaching mainly chemistry but would sometimes assist in teaching biology whenever there was a shortage of teachers in the school.

Tano had great interest in the science subjects when she was in secondary school. She said:

> …since I was in school, I actually had some inclination towards science subjects. I liked science subjects and more so is actually the teachers who were teaching me are the ones

> who motivated me to like these subjects. They used to teach well and also the way they used to conduct themselves even outside class, I used to admire it. So I just got motivated and inclined myself towards science subjects.

Tano's interests and motivation to pursue the chemistry were reinforced by her teachers conduct in school and the way they handled the subject.

Tano's education to become a chemistry teacher. Tano had joined Moi teachers' college (which later became a constituent college of Moi University), for a two-year diploma in science teacher education course after her advanced level studies. At college she did chemistry and biology, as her two teaching subjects, in addition to other subjects like physical education, library science, English, environmental science, and education. In education they did, among others, "methods of teaching, psychology, history of education, and philosophy of education." They were also exposed to industrial education to aid them in making teaching aids in schools.

The chemistry content covered in college was advanced compared to what they had covered at high school. They were only exposed to the chemistry content they were to teach in secondary schools when they were doing the subjects methods course, peer teaching and microteaching. On how they were prepared to be able to teach secondary school chemistry, Tano said:

> …well in terms of content, it was not really, it was kind of advanced from where, it was a bit of the "A" work then a bit of something above what we learned at "A" level (advanced level). There isn't really much to do…what you are really supposed to teach in the classroom. That time we did a bit, then when we were dealing with the subject methods. It is when you did a bit of that when you are doing subject methods, peer teaching and the micro-teaching. It is when we learned or rather we acquainted ourselves the content of what we were supposed to teach.

On her chemistry content level to teach secondary school chemistry, Tano put it:

> …well ah, by the time I left college, I can say that the level of the content was, you know with time if you don't rehearse something you don't forget. But when I left college, actually I could not just walk to class without really having to sit down, read a bit and

> prepare myself. But as I continued doing such, I think after the first year, I had almost all the content and I could just walk to class and just teach.

By the time she left college, Tano had to continue reading a bit as she prepared for her chemistry lessons. She became more confident in her chemistry content after teaching for one year.

Tano's chemistry teaching before the SMASSE project. Prior to the SMASSE project, Tano's teaching "was not really up to date because it was not really up to standard because I was actually teaching more of… theoretically and having very few learners' activities." Tano used mainly the lecture method to cover the chemistry content because the 8-4-4 (eight years of primary education, four years of secondary, and four years for a basic university degree) secondary school chemistry curriculum was broad and the students had to cover the syllabus in readiness for the national examinations. She said, "…like you realize when the 8-4-4 system was introduced, there was so much content and you see like the administration, they want you to complete the syllabus and say you have completed the syllabus."

The time constraints to cover the broad chemistry curriculum dictated the type of teaching methods Tano applied in her class and the kind of student activities she had to implement in class. She resorted to the lecture method and had a few class experiments to cover the chemistry syllabus for the students to be able to answer questions in the national examinations. On her approach to teaching chemistry, she added:

> So you were finding it very difficult to just have students here, may be for a double lesson, just doing one experiment. So you look at it to the one experiment, you compare may be with the much theory you would have covered within the same time. So most of the times, you teach more theory and okay, give them experiments just once in a while, may be just once in awhile you give them experiments. So it was more, I can say it more of lecture method and a bit of experimentation, a bit of it not very regular. And the, you realize that in such a case, okay, you were able to cover the syllabus.

This mode of teaching had not improved the students' performance in the national examinations. The students' performance in the national examinations continued to decline under the 8-4-4 education system. The SMASSE in-service education came in at a time when teachers had to look for ways of enhancing student achievement in the national examinations. As Tano put it:

> …but some years back before SMASSE project was introduced, you realize that the results were not good in chemistry because...I think it was because of the approach we were using, the results were a bit, were a bit poor. They were quite poor actually. But after we now came into SMASSE and then we started giving the students activities and we find that the results now are much better. Now they are much better, in fact we are doing quite well in chemistry, here in school.

Tano's willingness to participate in the SMASSE project in-service program started when it was announced that there were in-service education courses for science teachers in her district. As a head of the chemistry subject in her school, she had great interest to participate in the programs hoping that she would improve on her teaching skills and enhance her students' achievement. On how she came to participate in the in-service programs, Tano, said:

> …well when…it was actually kind of...it was announced that there is an in-service "training" for science teachers and [being head of a science subject] I said that I should also participate in it because as a teacher you keep on learning new things every now and then. So I was kind of eager to improve on my teaching methods and even before I received the invitation letter, I had already made up my mind that I am going to get myself involved in this project.

Tano was one of those teachers who had self motivation on enhancing their teaching skills in order to assist her students achieve better results in the subject she was teaching.

The major benefits Tano received from the SMASSE In-service Program. Previously, Tano viewed involving the students more on activities such as class experiments as wasting considerable amount of time that she would use to cover the chemistry syllabus content. It was easier for her to have lectures and where applicable spend little time to involve students in discussions. To her, it was easier to cover the chemistry syllabus content through explanations she gave to her students. As Tano put it:

> …It was more teacher-centered because I used to see like involving the students in my experiments I used to see it like I am wasting so much time, expecting too much from

> them. So I would like just discuss something and finish and not take so much time on it because like the activities, they take quite some time. The student activities take quite some time. So by that I used to think then I just explain to them they will understand. But I realized that they did not understand, unless they do it themselves.

Tano used to believe that having her students perform class experiments consumed considerable amount of time then if she explained the chemical concepts to them.

> …well it is the fact that the experiments, they take much longer time than explanation. You know when you are just explaining, like you are explaining you just talk about it, you say this, this but may be if it is a metal it reacts with water to form hydrogen and a salt. Then you just finish at that level.

According to Tano, preparing for class experiments took considerable amount of time as one had to arrange the apparatus, organize student into groups and have them perform the experiments. She commented:

> …you find that the business of now going getting the apparatus, arranging them, may be grouping the students in groups and having them carry out that, it will take not more I mean not less than forty minutes. It will take may be a double lesson. But this other one, you can just take a few minutes and explain that and finish.

Following the in-service programs, Tano was able to move from teacher-centered to learner-centered lesson planning and implementation. She prepared and implemented student activities during her chemistry lessons. Feedback from her students indicated that they understood the chemical concepts better when she employed her new approach compared to the lecture method she used before she started to attend the in-service education programs. On her new approach to chemistry teaching, she said:

> …one of the major benefits I have received is the fact that I have to involve the learner, and in what I am doing it should be learner-centered and not teacher-centered the way it used to be before. So, I have realized that when I involve the learners, I let them, I direct and I let them carry out an activity, they learn more…they learn more. Even when I test I find that they have actually attained more than the time when I was using the lecture method. So that is actually the major benefit, which I received.

However, Tano felt that with her new approach, in which she employed student activities in her chemistry classes, she still needed to look for extra time to be able to cover the broad 8-4-4 chemistry curriculum.

> …well if you compare the content and the time, you find that the content is actually quite a lot. It is quite a lot. So, even now when we employ these student activities we have to look for extra times so that we can be able to cover the syllabus. Otherwise if you just restrict ourselves to the time allocated on the timetable, we may not complete the syllabus. So once I involve the students on activities then I have to look for extra time to cover [syllabus].

Tano was full of praise for the SMASSE in-service teacher education. The in-service education had not only exposed her to more student activities in chemistry but also how to handle the topics that students found difficult in. She was able to teach abstract chemical content to her students with ease. On things she learned from the project that she was not aware of before the in-service courses, Tano said:

> ...I learned from SMASSE that that there are some of these topics, which the students find difficult, which can be taught in a very simplified manner and get to understand them very well. So I was able to employ some methods which made the topics which were abstract now become real and even simpler to the students.

According to Tano, students found organic chemistry a bit abstract because of the way she used to teach it. It was through the in-service education exposure that she was now involving students in various activities. She was using locally available materials to teach organic chemistry. She involved her students in making models and conduct simple experiments to prepare organic gases such as ethyne and compounds such as esters. As she put it:

> In a topic like organic chemistry for example, the students were really finding it abstract. They did not visualize how things like if you just even look at the structures of various compounds. So this time I am able even to get locally available materials and they make models. And then they [are] able to see how those atoms are, I mean how they bond to each other, the same with its structure and bonding. They were also finding it very abstract and they can use the same models. And then they can also carry out some simple experiments and prepare some of these substances, which the students have never come across, like some gases like ethyne and ethane. All those organic substances…can make

> those esters and they get that sweet smell and after that it is not easy for them to forget such [experiences].

Tano was happy that she was able to teach her students using student-centered approaches. Her new approaches to teaching chemistry benefited the students because they were able to understand some topic areas that were being viewed as difficult. During her class experiments she played a role of a guider to the students as they worked on their own. In her own words, Tano said:

> …Like now the methods, instead of just being theoretical all through, we have now, I mean, the students are involved in activities. They are given experiments. They are given experiments, which they carry out on their own and they can be able even to come up with the conclusions. As I guide them, they can just come up with the conclusions on particular issues on properties and structure, and all that. So the experimentation method, experimentation has really been helpful to the students.

Tano had diversified her teaching methods in which she was able to cover theoretical chemical concepts by having student activities, other than class experiments. She said, "then we also have the issue of ….giving them some kind of puzzles, concept word mapping and some puzzles, which they can play around with and you know they get to learn more in the process of doing that." The new approaches to chemistry teaching had made Tano to be able to enhance her students' achievements in school chemistry.

SMASSE's influence on Tano's design of the chemistry unit lessons. Tano argued that the lesson plan formats covered in many pre-service teacher education programs were very detailed. Teachers were able to write their lesson plans using college formats during their pre-service courses and student teaching practices. On graduation, many teachers hardly make their lesson plans following the format they were exposed to in college, partly because they find it a burden and time consuming and yet there was no enough time to cover the broad chemistry curriculum. In this regard, Tano found the SMASSE chemistry lesson plan format to be teacher friendly and influenced her lesson planning. The SMASSE lesson plan format had provision for the teaching/learning activities and lesson notes. Once one prepared the lesson plan, there was no need to prepare separate lesson notes. She was also able to plan for lesson evaluation as she designed her lesson plans. Tano said:

> …like when we were taught how to make a lesson plan at college, it was really, we were finding it really a burden and because here you have, you need to have a lesson plan, then you need to have may be lesson notes. But now, from SMASSE we have learned that you can actually match these two. You can match the lesson notes and the lesson plan and then it becomes teacher friendly and it also helps in the way you pass or communicate your information to the students. So as you go through those various steps you are able to see where may be you are not, you have not done it well and then next time you can improve on it.

According to Tano, she had made changes in the way she prepared her lesson plans following the SMASSE in-service education format. She was also able to make changes in the designing her subsequent chemistry unit lesson plans based on herself evaluation or the feedback she received in class. As Tano put it:

> …the changes like, one of them I have mentioned it, is the matching of the lesson notes and the lesson plans. That one I have really found it helpful because I don't have to duplicate work. I just do it and I am able to pass over the information to the students. Then other times you find that you can make a lesson plan and then you realize may be the lesson may take much longer than what you expected. So may be next time I will improve on it and may be you change it depending on the nature of the students you have.

On why Tano made changes in her design of subsequent lesson plans for her chemistry classes, she said:

> These changes are meant to accommodate the interests of the students because you find that like, may be this year you might have a very bright class. And if you have a class whereby majorities are bright, then your lesson plan should be made in a way to cater for the bright. Then may be the following year you might have average learners, so you have to modify it so as to cater also for average learners and also to cater also for the differences because all the students are not the same in the class. There are some who are very fast and others are slow. So you have to adjust it so that you cater for all the students.

Tano made changes in her subsequent lesson plan designs to accommodate her students' interests and achievement levels. By so doing, Tano was able to cater for individual differences in her chemistry classes.

SMASSE's influence on Tano's implementation of chemistry unit lessons. The SMASSE in-service education programs had influenced Tano's implementation of chemistry lessons. She was able to involve her students in performing learning activities in the topic areas they were having difficulties in. Tano talked of how she implemented her chemistry lessons involving the periodic table, "mole concept", electrochemistry, organic chemistry, and other chemistry topic areas she taught in school. Here I present her accounts on each topic discussed.

Implementing lessons on the Periodic Table. Tano said that her teaching had been influenced by the courses she took during the in-service education programs. She made her students carry out activities such as building the periodic table from given information. The student activities on the periodic table made them to understand the criteria for having various elements in particular groups or periods. On how she had been influenced by the in-service programs in implementing her chemistry lessons on the periodic table she said:

> …this program has influenced my teaching in these topics, like if you looked at, for example the periodic table, I have been able to handle the periodic table and bring it out very clearly to the students. Like we have been able to kind of come up with periodic table, whereby you can just place, you just have a blank piece of paper with blank spaces and then you can fix the various elements in various areas. The elements are there and then you get those elements and you can label them and fix them in a particular period and group.

As the students performed the activities, Tano was able to evaluate their understanding of the concepts involved. To reinforce the students' understanding of the concepts involved, she had them make atomic models in which they arranged electrons in various energy levels. She found the making of atomic models to be very interesting to the students. On students' activities, Tano added:

> …You can, by so doing you can know whether really the students have really understood what the periodic table is all about. We have also been able to come up with models of atomic structure whereby the students can arrange the electrons in various energy levels and that one it makes them, I mean it is so interesting they are involved and in the process, they learn better.

According to Tano, students learned the periodic table better when they participated in student activities during chemistry lessons.

Implementing lessons on the "mole concept". Following the in-service education programs conducted by the SMASSE Project, Tano was able to simplify the "mole" concepts to the benefit of her students. She had improved on the way she introduced the topic on the "mole concept". In her introduction she would relate the mole unit to the common units of measurement that students were familiar with in their everyday experiences. On how the project had made her change the way she taught the "mole concept", Tano said:

> …when you look at the "mole concept", the "mole concept" we have also been able to bring out the topic quite clearly and have it more simplified. Like for example, when I am introducing it, I normally tell the students a "mole" is just a unit, just the way you have a dozen, the way you have a crate. So they are able to liken it to that and then they are able to grasp the topic quite easily.

Incorporation of students practical experiences, made Tano's students to grasp the "mole concept" with ease. The students were able to view the "mole" as a unit of measurement just like the dozen or crate of items they are familiar with.

Implementing lessons on Electrochemistry. Prior to her attending the in-service education programs, Tano used to conduct few electrochemistry experiments. Occasionally, she could do demonstration experiments to illustrate an electrochemistry concept she wanted her students to learn. Somehow, students used to find the topic on electrochemistry difficult to learn. Tano said, “in electrochemistry, before the SMASSE project, I can actually say that we were not carrying out any experiments on this. And the students were finding it very difficult.” However, through the SMASSE in-service programs Tano was able to conduct various simple experiments that made her students comprehend the chemical concepts in electrochemistry with ease. She was able to conduct experiments on electroplating using simple apparatus. On her improved teaching skills, Tano put it:

> But with the introduction of the SMASSE project we have been able to carry out quite a number of experiments on electrochemistry. Like we can demonstrate a bit of electroplating, just using some very simple apparatus. Electroplating using just very simple apparatus whereby may be can have a coin and you have another end with copper, you coat this coin with copper by just passing the electric current and the students are really appreciating that.

In current chemical education, it seemed that teachers do not “see” how they can relate electrochemistry concepts such as electroplating to simple things students experience in life.

Tano involved her students in making simple cells using locally available materials. Student participation in such activities assisted them to understand the chemical concepts involved, concepts otherwise they found abstract to them. Using improvised materials, the students were able to measure the potential differences of metals and develop an activity series for them. Tano said:

> We have also been able to make up some simple cells because with the students the simple cells they were looking quite abstract. But now we can make it even using some fruit. Just something very simple, you have an orange and you can [connect] the electrodes and measure the electrode, the potential difference and see how may be how the potential difference is increasing as the metals [are changed], is the difference in the activity series between the metals they have. So you can demonstrate that quite comfortably and the students are to appreciate that.

The students appreciated learning electrochemistry as Tano involved them in various learning activities. They learned the electrochemistry concepts with ease through the simple experiments, demonstrations, or improvised items used by Tano in class.

Implementing lessons on organic chemistry. Prior to the in-service programs, Tano had thought that it was not possible to perform many experiments found in the chemistry textbooks in the school laboratory. For instance, she had never prepared ethyne or ethane gases and polymers in school. The SMASSE in-service education courses had prepared her well to be able to conduct many experiments in organic chemistry, experiments she never dreamed of doing when teaching school organic chemistry. On her improved teaching skills and lesson implementation in organic chemistry, Tano commented:

> Then in organic chemistry, also we have been able to carry out quite a number of experiments, which before we thought can not really work, like preparing ethyne, preparing ethane we have been able to do that. We have been able to also prepare some polymers.

Tano involved her students in making models of organic compounds. The models helped the students in learning how to name the organic compounds, an area which some students had problems in. The new approach of Tano in teaching the organic chemistry had enhanced her lesson plan implementations to the benefit of the students. As she put it:

> And we have been able to really involve the students make the models. And in the area of nomenclature, we have been also to, okay, make those models and those molecules, the compounds, name them. So it has actually been quite good, we have improved quite a lot in that area.

It was Tano's feelings that she had greatly improved in her organic chemistry unit lesson plans implementation. The improved lesson presentation in turn benefited her students. She had made all the changes in her lesson plan presentations following the SMASSE in-service education courses, and perhaps because of her participation as a cluster in-service educator.

Tano's motivation and improved teaching skills had made her to extend what she learned during the in-service education programs into other topic area such as energy changes. In her words, she said "we have actually been able to carry out some experiments in energy changes and even determine some enthalpy changes practically. And the students have actually become well acquainted with that." From Tano's discussion it was seemed that the SMASSE in-service education programs had had a positive impact on her and she had greatly improved on her teaching and improvisation skills.

Changes Tano made when implementing her subsequent chemistry unit lessons. Following the in-service education programs, Tano had realized that she could plan and implement practical-oriented lessons for her classes regardless of the amount of time allocated for such lessons. In Kenya, chemistry is taught in every week of the term. Usually there is a double lesson, meant for a practical session, and single lessons meant for theory sessions. Prior to the SMASSE in-service teacher education programs, teachers conducted class experiments or teacher demonstrations or theory lessons during the double lesson sessions. In the single lesson sessions, teachers sometimes performed teacher demonstrations in addition to the theory lesson. This mode of teaching arrangements meant that many teachers hardly used to prepare for student activities, partly because of inadequate resources for experimental work in school or the examination-oriented curriculum. However, Tano's exposure to the SMASSE in-service education programs had made her to plan for lesson evaluations which assisted her in making improvement changes in her subsequent lessons. She had changes in her subsequent lessons "so as to make learning better…as I teach." On the changes she made in her chemistry lessons, Tano said:

> Now, like in the lesson, I have actually come to realize that you don't really have to wait until maybe you have a double lesson. We have one double lesson in a week. I have come

> to realize that you don't have to wait until you have a double lesson for you to demonstrate or have the students be involved in an activity. Before I had to wait until there is a double lesson. But now you can [do] just some very simple, very simple experiments, which will take just very few minutes, very few minutes you have them and there you are able to achieve your objective without much struggling.

Tano gave some examples of the simple experiments that she conducted in her classes. She cited the endothermic and exothermic reactions involving sodium hydroxide and potassium nitrate which one can perform to demonstrate the heat changes in chemical reactions. Using the experimental results, one will be able to explain the energy level diagrams to the students. As Tano put it:

> Yeah, like if you look at like in energy changes you can actually demonstrate an endothermic and an exothermic reaction quite easily by using sodium hydroxide and potassium nitrate. That one will just take you very few minutes and you are through with it and then you can actually come up with that energy level diagram whereby you explain to the students and tell them this one is giving out heat. So the reactants will be at a lower energy level than the products. This one is absorbing heat, so it gaining at the end the products will be at higher energy level than the reactants.

From the discussions, it was evident that Tano believed that her students were able to learn chemical concepts with ease when they performed and participated in chemistry learning activities. In her view, properly implemented chemistry lessons enable the teacher to achieve the lessons' objectives comfortably.

Findings from the Focus Group Interviews: Simba District

Reasons for participation in the SMASSE in-service program. Tatu believed that learning is a continuous process and had to participate in the SMASSE in-service education programs to improve himself as a teacher. Tatu said, "…I totally thought that if I participate in that program it is going to improve my experience as a teacher and I will also have a chance of sharing with other people in the field." Moja, supporting Tatu, said:

> …apart from becoming improved as a teacher, I personally expected that maybe I will get a certificate which will lead me to be promoted as a teacher and in which case I would

> have seen my career advancing. And looking at it from the fact that it was actually a foreign, partly sponsored project, I also thought that maybe I will fly out of the country and learn more about what is going on around the world.

Moja had thought that he was going to become a well traveled man on joining the SMASSE project in-service programs. He thought that he was going to be removed from high school classrooms and be involved in in-servicing teachers. He observed that:

> …I also thought that, maybe, I was going to be removed from the classroom, as a classroom teacher, and go to teach the teachers who are now who are going to remain in the class because after being subjected to a rigorous interview, you did expect really to come back to the classroom but to become somebody who will be "training" others.

Mbili concurred with Tatu and Moja, but she had already been interested in the project because a SMASSE Project team from the headquarters had previously visited her school and she had attended a seminar that was facilitated by some of the project members. She observed that:

> …actually what even made me be so much interested before this, I think we had a group that had come from Nairobi and there were some seminars for science teachers. And the material that was handed during that seminar was very very important to me because they were talking about the syllabus covering, sometimes where you don't cover the syllabus how you waste time, how we have [inaudible] teaching improved and things like that. And so when I heard that there was this SMASSE in-service "training", I thought if I joined that SMASSE I will be a better teacher and I will know how to handle the students better and I would get better results.

By joining the project to be educated as a district in-service educator, Mbili hoped to become a better chemistry teacher leading to higher achievement scores for her students.

Teacher expectations of the SMASSE in-service program. Mbili expected to get a certificate after the four-year in-service programs. She also expected to be promoted "from one job group to another" and therefore earn more after the in-service programs. She also expected to travel as she educated other teachers during professional development programs. In agreement with Mbili, Moja expected to be awarded an educators certificate that was to give him an edge over others. He said:

> …I also thought that maybe this certificate you were talking about, you know the certificate in this country of ours gives you an edge over others maybe you are going for an interview or there is [a place] where a certificate is asked.

In addition to his colleagues' expectations, Tatu put it:

> …I thought I will have a chance of going for further studies. You see like to be an effective "trainer" of "trainers" as some of us we were [expected] to be, then, we have to advance in our studies. So I thought the organizers had that in mind. They would send some of us for further studies so that in that we would be better placed to come and "train" others.

However, the participants had only benefited from the programs in terms of teaching methods. Moja said:

> ...After "training" this long I think somehow my expectations have actually not been met, most of them if any. The only thing I can say has been met is the fact that maybe now I am a better teacher but in the area of certificate I think there was this idea of us becoming "trainers" and the certificate was supposed to be special. It is unfortunate that the certificate for "trainers" was never given and also when we go for interviews and for promotions, those who have not even attended the SMASSE sometimes have an upper hand, which means that this one has really been…I think has not augured well with us.

Tatu felt that the few teachers sent abroad for short-term courses had come with no concrete certificates to show that they had been prepared in advanced teacher education courses. They expected those prepared to be educators in the in-service programs to have advanced teaching skills in chemistry. Tatu said:

> Yeah, there are programs of sending others abroad but they have come back we don't see them with any concrete certificate let's say something like a diploma, or certain degrees. They just go for some courses which are not really specified and then they come back. And moreover the ones who have chances of going, they are very few.

Mbili argued that her expectations of becoming a better teacher had been achieved because her teaching skills had changed. She thought that she would be promoted after being involved in the in-service program for five years. However, this was not the case. The SMASSE district in-service educators had no added advantage over their colleagues who opted to pursue further studies at the university. She said:

> ...it has taken us four years to go through the "training". There are some of us instead of them going for SMASSE they went for further studies. They have finished their master's degree. Others have finished some diploma courses. And those people have got promotions. They have gone to; maybe some of them have gone to a higher job group than us. Others have got better jobs elsewhere like those who went for guidance and counseling.

The in-service educators' continuous participation in the education of chemistry teachers at the district level for four years had not been properly recognized by the SMASSE national in-service education administrators and the teachers' employer. Mbili observed:

> But you find now for us we were in SMASSE for those four years and we are still where we were, not even a job group, no salary [increment]. And it is like that even where we are, you know there is no indication of saying that we have done something extra. We are just like we have not done anything and you know as a human being, we feel there should have been something, you know a token of appreciation. We have done that; we have "trained" teachers. At least somebody should come up and appreciate [our efforts].

Moja concurred with Mbili that the national SMASSE administrators were not appreciating the district in-service educators' efforts in educating the chemistry teachers. The educators were left demoralized because of the administrators' insufficient support and recognition of the role played by the district in-service implementers. The district educators were devastated by the fact that they were to be given teacher educators' certificates that were to expire after five years. This was a new development to many teachers who had not known that issued certificates can expire after certain duration. This, somehow, influenced some teachers to leave the program for various reasons, partly to pursue further studies or seek other job opportunities. The administrators' actions demotivated the teachers. Moja added:

> You know like this the last time, we were told by the head of the in-service that this [SMASSE certificate for the district educators] should expire after five years. So this alone is really demoralizing to the teachers who are taking this course. No wonder you can see even those who have been taken across to Japan by this SMASSE project in fact they had abandoned the project which is supposed to in-service during the holidays. They have joined now the university, just as she has said. So this is a clear indication that motivation is not enough in this project for the teachers because if you can go for a certificate which expires after five [years], then it is better you go for a degree which will

> never expire for the rest of your life. So this is another area which actually with that [inaudible] and it is really demoralizing.

The SMASSE planners seemed to confuse the participants on the type of certificates expected to issue to them. This seemed not to motivate the in-service teachers and some of them opted to abandon the project in favor of the university education. The in-service that some selected teachers attended abroad seemed not to have much impact on the recipients as some of them had also left the SMASSE project. Moja argued, further, that:

> You see you have the people who went to Japan, they have stayed in Japan; I don't know that was for three months. When they came we were given this idea that SMASSE participants' [certificates] will only last for five years. Then when the "trainers" actually sit and reflect on the importance of these certificates they didn't find much significance in having the certificate because for one the certificate is going to expire in those five years before you are [even listed] in getting a promotion if there is any.

It seemed the participation certificates issued by SMASSE or institutions outside Kenya did not assist the in-service teachers in their promotions to the next teacher grades. Concurring with Moja, Tatu said:

> In SMASSE, a few participants have been taken abroad, to Japan and recently I have heard somebody going to Philippines. But you see when they are coming back; they don't come back with certificates which can be recognized outside SMASSE. Something like a diploma or a degree. They go there and they stay for more than one year, when coming back they have just participation certificates and not [strong] certificates which can be universally recognized.

The expiry of the educator of educators' certificate was negatively influencing teachers who were supposed to participate in the in-service programs. The educators found the SMASSE Project participation certificates meaningless to them and some preferred to pursue courses that provided lifelong certificates to those of the SMASSE Project. As Moja put it:

> So they expected to go for the certificate which is less than for example if you have my B. Ed degree, I will die still having the B. Ed degree, I will not be told that at one time my B. Ed degree is going to expire. So if you have your master's, the same case. So the people have now decided, the "trainers", to abandon [this thing] which is short-lived to go for something which is lifelong and that is a degree certificate from the university. So

> that is where SMASSE would have also emphasized and seen how the certificate can be as meaningful as maybe the degree that a teacher gets.

Tatu felt that if the SMASSE in-service planners had meaningful certificates for the in-service educators, perhaps this would have curbed the exodus of the educators from all levels of the in-service programs. Tatu observed that:

> …you see it is not only that some of the participants who would have abandoned SMASSE. I think a few and some of the national "trainers" are also leaving, which could mean that the pastures are not that all green at all levels.

According to Tatu, the certificates were supposed to be provided by the Ministry of Education and the coordinator of the SMASSE Project, in consultation with the head of the In-service Education (INSET) Unit and the national "trainers". Tatu supported Moja's assertion that the SMASSE administrators were not consistent with what they told the in-service education participants. He said:

> After the three cycles that is after three years we were initially supposed to be given certificate of "trainer" of "trainers". The district "trainers" were supposed to be given that certificate. But instead the promise was extended to a fourth year and even after completing that fourth year still there were no reasons given as to why the certificate should not be given. So here then as a participant's point of view, there is some kind of uncertainty, which made some of us expect that the organizers were not very sure of what they were doing.

The participants were assured that the SMASSE certificates were to carry considerable weight, especially when attending interviews for promotion to next teacher grades. However, this was not the case as the SMASSE in-service participation certificates were not recognized by many of the interviewers. As Mbili put it:

> …and of course another thing when we joined SMASSE that we were told that once you have that SMASSE certificate it will **carry** a lot of weight…if you are going for an interview with that SMASSE certificate you know it will carry a lot of weight. But for the few of us who have gone for such interviews it looks those SMASSE certificates, you know they are not even recognized. So you know and when you go to such interviews and you [know] some of them will ask you what this SMASSE is. So it looks like

> something is [not] happening because whatever we are told, it is not [taken in] and you know that demoralizes the teachers.

Tatu supported Mbili's assertion that "most people don't even understand the certificates" by saying that:

> …when you go for an interview let's say for promotion, being a SMASSE participant or district "trainer" does not give you an advantage. The participation certificates we have from SMASSE they are just considered to be like any other certificate, any other persons attending the interview have. So the SMASSE participation certificate does not place [one] in any special position.

In Kenya, the promotions are effected through interviews. One serves in a job group at least for three years to be eligible for promotion to the next job group through an interview. The participants observed that in the SMASSE project the educators were heavily involved as they underwent extra in-service education course. They argued that a SMASSE district educator contributed more to the development of education in the district than a head of department in a high school. So they expected the SMASSE participants to be promoted on merit. However, they argued that the efforts of the SMASSE participants were not readily met by the project administrators. The in-service educators had to wait to be promoted like any other teacher in Kenya from one job group to another despite the fact that they had been educated and in-serviced their colleagues for four years. The teachers can also be promoted under special circumstances such as automatic promotion when appointed a school administrator or when one attains higher professional qualifications. As Mbili put it:

> …I think there is also another way of promotion like for example if let's say you are a diploma holder and then you go in for another two years, three years and then you get a degree. I think there is also an automatic promotion. So we were taking it that when you go through this SMASSE program for four years, you know you have even done more than this person who has gone in for a master's degree. So we are feeling that these people who have gone through this SMASSE should have a credit and then be recommended this is one has done this for this time. So at least should be pushed to one job group.

Tatu reinforced Mbili's assertion on the types of promotions available for teachers in Kenya. Tatu observed:

> …I would like to comment on two other ways of promotion in Kenya. There is one like along the administration lines. When people join administration, they are automatically promoted. Then there is another way [of] promotion through a special merit.

On the other hand, the district educators' team leaders happened to be senior teachers and heads of departments in schools, but were not being appreciated by the project administrators. This had a negative impact on the in-service education as some of them had abandoned the project. As Moja put it:

> Those people who are in SMASSE and it is the one which has also demoralized those people who have left SMASSE. You can imagine that while you talk of people at the district level who are supposed to be the heads like our case here is Mr. Onamu (referring to the district in-service educators' team leader). On the other side from Chui (referring to the neighboring district which was also participating in the SMASSE project), the person who is supposed to be like Onamu from Chui, has left to attend a degree course, which means that this one is not motivating to the teachers [to] keep them remain in that area.

Moja observed, further, that the district in-service educators were being demotivated by some exodus of other educators from the project. He said:

> ...You see if you are the leader and then you decide to also leave SMASSE so when you go to the national "training" we are told that so and so has left the "training" and is now maybe taking a masters in Kenyatta University and so and so has left and is taking a course in Nairobi University (referring to The University of Nairobi). So us now at a lower level, district level, if those at the national can leave, then we can not [see] the reason why we can actually succeed in this SMASSE. So that I think has also been a demotivating factor to us.

The district in-service educators' workload remained the same in school, while they were expected to be in-serviced in the month of April of each year and conduct district in-service programs in the months of August and December during the five-year project duration. The in-service educators were overworked because of the increased workload on them. Their influence on the enhancement of chemical education in their districts was more felt than that contributed by heads of departments in schools. Tatu said:

> …now coming to the question you have just asked how a SMASSE district "trainer" contributes more to the science education than a head of department, you find that this SMASSE district "trainer" is "training" very many teachers, whereby some of them are even heads of department. And [they offer] a lot of useful skills and knowledge and so on to teachers from the **whole** district. A head of department you find that is just restricted to his school. In fact most of the time, he is mainly serving students. And in very rare occasions he is coordinating and organizing teachers. So in that way you find that the SMASSE district "trainer" is contributing more in the development of science education in the district.

On the district in-service educator's increased workload, Moja noted that:

> ...as a district "trainer" you have to prepare what you are going to teach the other teachers from the other schools. So if you don't have enough time to sit and prepare then the materials you might give these teachers may also be substandard. So you have to have left work in school so that you prepare for the in-service "training". Actually here as a SMASSE "trainer", I think it is not a question of waiting until April when the in-servicing is taking place. As a "trainer" in SMASSE we are even supposed to meet and organize for other seminars apart from the INSET that is normally given during April time. But you see because the much workload we have you cannot organize a seminar. It is a bit very difficult for us. If it is reduced then maybe it is possible to organize seminars and workshops.

Mbili concurred with Tatu that district in-service educators were useful to other districts that were not covered by the SMASSE pilot project. She said:

> …but in the same time you find that there is even these districts that they are not under SMASSE project right now but used to be. And then once you know you are a district "trainer" you are going to go and facilitate in some seminars [and also "train" in these districts]. So I support Mr. Tatu that a district "trainer" really **does more** than just a head of department because you are used not only in your school but in other schools and even in other districts.

Tatu critiqued the structural organization of SMASSE in-service program implementers. He felt that there ought to have been a structure in which those who were cluster educators were to be elevated to become district educators and those at the district level to be promoted to the position of national in-service educators. He noted:

> Actually somebody will expect that a cluster "trainer" at one time would move to be a district "trainer" and a district "trainer" also would move to become a national "trainer". But there seems not to be such an arrangement in SMASSE like when they organize national positions they discouraged "trainers" from applying. So that one was rather abnormal and out of the ordinary and it is hard to be described in some particulars in the project.

The expansion and recruitment of the national in-service unit personnel was done in a manner that left many district educators dissatisfied. District in-service educators were discouraged from applying for the national positions with a view that they were to continue strengthening the district in-service education. However, the national in-service office continued to recruit new personnel who had no experience on the SMASSE in-service education, while later on other district "trainers" were selectively chosen to join the national in-service team without any knowledge of the other district educators. Tatu observed:

> …that is what they are saying but especially when at some times it appears on papers. They say that district "trainers" should not apply but they are not consistent because of late there are district "trainers" that are already in the national, they are national "trainers". So I think they are also not consistent. They should come up [inaudible] if it means that no district "trainer" should be a national "trainer", let it be so because like now here it comes, it looks as if there is discrimination.

From the discussions, it seemed that the national in-service administrators were not consistent in their management styles, a situation that made some district in-service educators feel as if they were being discriminated upon.

In-service educators' expectations met by the SMASSE project. The participants argued that some of their expectations had been met while others had not been achieved following the in-service teacher education programs. Tatu put it:

> Yeah, some expectations have been met and some have not been met. Like improving our teaching skills, to some extent, that one has been met, and also changing our altitude, making it more positive so that if the same can be achieved with the students. I think that one has taken place. Even we also had this problem of gender, that girls were generally not being encouraged to participate more in science and mathematics. That one I think

> through SMASSE, what we expected to be improved there, I think to an extent has been achieved.

The participants had improved on their teaching skills and developed positive attitudes towards the teaching of chemistry in relation to gender issues and students' learning environment in school.

The in-service programs' organization to meet participants' expectations. Moja felt that there were two aspects that needed to be addressed in order to meet the district in-service educators: improving the teachers' teaching skills and to motivate the professional teachers. The teaching skills had been improved but the in-service educators were still demotivated because of non recognition of their enhanced teaching skills by the relevant authorities. The district in-service educators expected to have salary increments or promotions to the next teacher grades. But this was not so during the five-year in-service programs. Moja said:

> ...there are two aspects here. There is the aspect of improving the teacher in teaching the students. Then there is the aspect of motivating the teacher now in this profession. And of course this is material. So maybe the first start of improving the teacher in his teaching skills it has well been done but on the other side when we talk about the material, that one I think is just a question of liaising with the Ministry of Education so that these people once you have attained your certificate after the four years now, they can maybe reward you materially. And this will go along way in motivating the teachers.

Tatu observed that "the reason why SMASSE was started is to improve the capability of students, the youth, in mathematics and sciences. And, of course, one way was to improve the teacher in methodology and so on." He argued that there were factors that affected the teaching of chemistry in schools. Many of these factors were beyond the SMASSE in-service education project. There was need to diversify the in-service programs. According to Tatu:

> ...there are many factors [that seem] to affect performance and capability of youth in mathematics and sciences and even SMASSE found that there are also limitations. There are problems which SMASSE can not address. And in that occasion you find some of those factors are the ones which are really hindering the advancement of the youth in

> mathematics and sciences. So I think a way should be addressing those other problems which SMASSE can not address.

Mbili, while acknowledging that she had become a better teacher following the in-service programs, she observed that there were other problems such as lack of materials to teach chemistry in rural schools. Some school heads thought that the teaching of chemistry was becoming expensive in their schools because of the SMASSE in-service programs' emphasis on student activities. She said that:

> Although sometimes I have the skill and I can do this but it comes to a time when I do not have the materials to use and so I don't know what I would say, if maybe because the way I am looking at it, it looks like even some of the head-teachers, you know, are not conversant with the SMASSE, some of them are still negative. They think that the science teachers are becoming very expensive.

According to Mbili, the SMASSE in-service education planners ought to organize seminars "for these head-teachers so that they can avail the materials required." Teachers also need to be sensitized on how to organize group activities for students' maximum benefit in learning chemical concepts. She narrated an experience she underwent when doing some small scale experiments in her school following the in-service programs. Her colleagues felt that she was spending more chemicals and using many apparatus. Her colleagues believed that when the students were exposed to many apparatus there would be more breakages leading to a shortage in school. For them, large groups were ideal for the chemistry experiments in class. She noted:

> ...you know the way we learned in SMASSE but still the head and the other teachers, the way they are used to, they feel that you know that is using too much. You know why are you organizing an experiment for five people? Can't you put ten in one group? And so as much as you have the skills and we have the materials we are finding it sometimes hard to impart the information we have because of the surrounding [failure] where we are working. So if some things could be done let's say sensitizing these teachers I think it will help us.

Tatu argued, further, that in Kenya "the teachers have a curriculum being reviewed a lot." The frequent changes in the chemistry curriculum required new textbooks. Provision of these textbooks in schools, following the frequent curriculum changes, was quite expensive to schools. Perhaps, a system in which the Kenya Government provided funds for the provision of textbooks in public secondary schools might help as is the case in the public primary schools. On the issue of textbooks, Tatu said:

> But you find that after a short time some books you were using, some resources you were using, have become irrelevant. Like now the students each time after about three years, they have to buy new books let's say for chemistry, and that is quite expensive. There I would support Madam Mbili that resources are a problem, especially resources to implement the curriculum is a problem. So that here I will suggest that the current system of primary education we have in Kenya, that idea could be extended also to secondary school so that funds are provided for acquisition of material.

Moja observed that chemistry teaching in many schools in their district seemed to be examination-oriented. He argued that examination-oriented teaching was a problem in schools in which teachers wanted to teach based on the skills learned during the in-service programs. The teaching methodology emphasized during the in-service programs required more materials for student learning activities. This was seen as an extra cost to schools, which some schools were not ready to meet. Moja said:

> You know when something is exam-oriented it is really a problem to teach because like Mrs. Mbili was talking about materials, you will find that the head-teacher will not want, maybe you to carry out activities which are involving any cost, not that they are not actually expensive but even the minutest of all the cost, if that thing is not in the syllabus and therefore to appear in the exam or it has never been tested before. So you will find that maybe the students are going to see these things when they are about to do the exams and sometimes the schools will borrow from other schools. So this makes it also **very, very** difficult.

Moja felt that the SMASSE in-service education project should also be dealing with the in-servicing of the heads. "They should be told that teaching is not only meant for examinations but it is also meant to enrich the students with the knowledge. And this should also go a long way to convince the students that it is not all examinations." The students ought to understand the chemical concepts they have to apply in their real life situation and not just to answer the national chemistry examinations questions. The situation is partly supported by the job markets that consider the grades attained in the examinations and not how well one is able to apply the learned concepts in real life situations. As Moja put it:

> ...we tend to reward people whoever, even if they had to read for exams we reward them well in jobs and so on. So this one will make the students read only what they think should appear in the exams and therefore anything that like telling a student to prepare hydrogen sulfide, for example in the lab, and he knows this...one may not even come in the exams. So the student would not bother to prepare such gases or the experiments which are explosive like the burning of hydrogen [because] they know they will not be asked to burn hydrogen in the lab. So you find that the students will not be very serious about those things which will not work in the exams or anything which again falls outside the chemicals that we had. For exam even if you were to bring cells and you want the students to test for the presence of calcium or phosphorus, although they know that cells cannot be brought in the exams for them to test. So they will not go that extra mile to try and find out other chemical substances in the other things that we have in the day to day life.

Moja thought that another very important improvement to be done would be on the management of funds at the district level. The money given to the district educators for transport and pocket money to attend or conduct chemistry in-service education was not adequate. According to Moja most of the money withdrawn from SMASSE district in-service account went to the district project coordinators and managers. To avoid the issue of vested interests in the in-service education kitty, Moja felt that the in-service education monies should be left to the district in-service educators to manage as they were the implementers of the in-service programs on the ground. By so doing the subject associations can be funded and materials bought to run the common district examinations. Moja said:

> ...they should take measures whereby they entrust the responsibility of the expenditure of this money to the district “trainers” so that at least they are aware of what is being done. But if it is something that the “trainers” are going to see a vote of the people to go enriched with the parents money which is supposed to buy materials like what madam has just said here. If this money which every student, I think contributes a hundred to SMASSE kitty in the D.E.O’s [District Education Officer’s] office, if this money was used then organizations like NACE [Nyati association of Chemistry Teachers]…can run on those costs so that they can buy papers and make marking schemes distribute them to

> the teachers out there but now because this money is channeled to wrong directions then it leaves the organizations which are actually…very instrumental in the teaching of chemistry in the district.

The district education managers and the SMASSE project planners seemed, in the opinion of the educators, to overlook the important role that subject associations were playing in enhancing the teaching and learning of chemistry inn the district. The SMASSE management and planners were not only frustrating the district in-service educators efforts in coordinating teachers to have appropriate schemes of work in their schools and have common examinations in the district but they were leading to the downfall of the district chemistry subject associations. According to Moja:

> …those organizations are actually dying out because the heads from these other schools are not funding them and last time we were talking to the D.E.O's office about the organizations, we were told that these are not recognized in the ministry. Actually that is what I was told that these things are not recognized here in Nyanza. What we have is now SMASSE. So you just do away with that. So we will be having this SMASSE only during the holidays and these organizations where we meet, analyze the students' papers, make common schemes and even give activities of various topics that a teacher can use to teach are no longer going to be there. So now the exchange you know SMASSE actually was here basically to give us, it is assumed that we have the knowledge but you may have activities that I don't have. So it is meant that I show you the activities to give your students, you show the activities I also don't know. Now, which forum are we going to have for such exchange of such ideas if the organizations are dying out?

The participants concurred that if the money collected for professional development of teachers in the district was well used, some of it could have been utilized in the district chemistry teacher education organizations. The involvement and strengthening of the district chemistry subject associations in the in-servicing of teachers and coordinating the teaching and learning of chemistry in schools was likely to be felt positively by the stakeholders.

Role of district in-service education resource centers. At the start of the SMASSE Project in the district, there was a chemistry teachers association, SACE. Tatu observed that they later learned at the national level that the chemistry associations were not directly under SMASSE.

According to Tatu, “these associations were doing more for most sciences because it is in those associations that they used to meet and talk about reforms in science education, talk about how to set exams, how to analyze examinations, how to prepare common schemes of work, and some contests.” The national SMASSE office’s reluctance to sponsor the chemistry associations in the districts had undermined the enhancement of chemical education in rural schools. The district in-service education resource centers were found to be only useful during the in-service education sessions. Tatu said:

> Now the district unit as such, I mean that one is only useful during the INSETs. Otherwise all the other times it is closed although we used to find that from the association, our chemistry association, we would go and borrow materials from the INSET Unit. But now officially it is not supposed to be so. So I will [say for] the district INSETs, they only assist during the in-service “training” but the other times it does not directly assist the teachers in promoting the chemistry education. And also you see the administration becoming a bit difficult like a teacher can borrow text books from the district INSET Unit and a number of them used to return them. Following them up will become a problem.

At the inception of the in-service programs, the participants thought that their chemistry subject associations were to benefit from SMASSE Project in coordinating the district’s efforts to enhance the teaching and learning of chemistry. The district educators hoped to receive technical and material support from the project in setting common district chemistry examinations and organizing for chemistry teachers meetings to exchange ideas and experiences. As Mbili put it:

> …if we have a common exam to set in the district, you know we thought that after we have set the exams we would approach the SMASSE [project] and maybe help us “clean” the paper or something like that. But then when we were making a follow up I think we were told that we do not [complement] each other. And so what happened is that, you know after I mentioned about the materials earlier on, there are some of the head-teachers who are very hard on giving out anything. When we started setting common exams and then we say can the schools now bring money we buy paper and we print the exams, some people were just withdrawing because they could not raise that money and so we were thinking that if maybe the SMASSE [project] would come in and give some little material maybe others could be encouraged.

It seemed that the SMASSE Project planners were not keen on the district subject associations, which the participants felt were important in coordinating professional development activities for science teachers.

SMASSSE program aspects that were most significant to the in-service educators. The participants found the ASEI movement, PDSI approach and improvisation very important aspects of the in-service program. The in-service had exposed the participants to many student-centered activities that enhanced teaching and learning of chemistry. The in-service programs had also made the participants to plan for and have continuous lesson evaluation during lesson implementation. Moja noted that:

> …the part of SMASSE which was significant to me was improvisation and the PDSI. Initially you know these things we had been taught from college but there is an emphasize from SMASSE I could say the ASEI, all those activities were there but they were not as much as we have now. So the emphasize on improvisation that one has really assisted us in increasing the number of activities that the students are doing and also the part of evaluation where we are able to evaluate a lesson as it goes on so that by next time you are coming to teach in class you don't have to prepare for something else when the students had not understood the previous topic.

The in-service programs had helped the district in-service educators to be able to accommodate gender issues in their chemistry sessions. Mbili said:

> …there are aspects like gender for those of us who teach in mixed schools. You see from our culture, the girl child is not encouraged to participate in science education but you see SMASSE emphasize this aspect of gender. So that those of us who are mixed schools you find that we have consciously to encourage the girl-child to participate in let's say chemistry. So I think that aspect of gender has really featured in SMASSE. I will also…that in this SMASSE we have been able to come up with more teaching and learning activities. Before we had limited range of activities, but after participating in SMASSE we have been able to share and come up with more activities to make especially topics of concern livelier.

Prior to the SMASSE in-service education courses, the educators hardly thought of the gender issues that hindered effective teaching and learning of chemistry, especially in mixed rural schools. A people's culture influenced their school going children's participation in learning chemistry. It seemed that the in-serviced teachers' chemistry sessions were accessible by all students and there were provisions for equity in the classes.

Significance of the SMASSE in-service education program. Tatu argued that those aspects that were hindering advancement in science education had been addressed by SMASSE. The teachers were able to advance their teaching skills that were likely to lead into increased enrollments in chemistry classes and the improvement of the grades of the students in the national examinations. Prior to the in-service education programs, the educators used to evaluate their lessons through question and answer techniques. The in-service education curriculum exposed them to more ways of lesson evaluation to enhance subsequent lessons' planning and implementation leading to better students' learning of school chemistry. Mbili said:

> ...about the aspect of evaluation, of course I used to teach…every time I would do my evaluation through question and answer but I noted that as much as you know the students could answer some questions in class then I would [assume that] of course they have understood. I noted that there are other small, small things [that] hinder their learning but they are not able to come forward. You know they are scared if I tell this to the teacher something maybe done to me. And so what I learned is that I can improve my evaluation by let's say giving the students some paper and you know let them to say anything they think can help [in maybe] teaching. And so I learned that in that way the students will share a lot and some of these are **very, very important** points that will help improve in the next [lesson].

The educators felt that their new format of having their students evaluate their lessons helped them to know their students' constraints in understanding the chemical concepts being taught in class. The students were able to express themselves freely and confidentially in written on how they found the lesson and which areas they wanted their teacher to address or improve on in the next lessons. In this regard, Mbili put it:

> So I said of course we do it but you know there are those other things the students cannot tell you or a student cannot tell you to do, you are in class and you are very harsh, why are you harsh? You know something that or they can tell you, you are moving so fast, something like that but when it comes to these evaluations, I think they tell the truth and that can help us improve our learning.

The in-service educators found the aspect of improvisation in teaching chemistry in the rural schools very important during their in-service education programs. Prior to the in-service education, the educators would plan for teacher demonstrations or class experiments whenever the conventional apparatus were available in school. They avoided those experiments that they taught would not be done in the school laboratory or simply they would not do any class experiment because the chemicals and apparatus mentioned in the class textbooks were inadequate or not available in school. With the SMASSE in-service teacher education, the educators were able to perform many of the experiments that they never used to have their chemistry classes do. Mbili said:

> …you know in the past most of us just used to teach using the telling you know strictly what we had in the convention methods in the text books. But now from improvisation, we saw that you can use these local materials and you know you can make some of the apparatus and then you can carry out the experiment.

However, the educators were in a predicament because of the examination-oriented chemistry curriculum. Students were more concerned about passing their national examinations regardless of how useful and applicable the chemical concepts were in their everyday life experiences. Performing teacher demonstrations and class experiments using improvised apparatus was challenging as teachers had to cover the set up of conventional apparatus for a given experiment in theory. This was important because the national chemistry examinations had practical and theory papers. The questions in these examinations involved conventional apparatus and not those improvised. On use of improvised materials in teaching chemistry, Mbili continued to say:

> But in fact now again there is a danger to this because actually when it is electrolysis I improvise the Hoffman's apparatus alright but you see now when it comes to the examinations, you know, these improvised apparatus they will not come out. And you see you find that the students are getting confused but otherwise that aspect of improvisation at least it helps them. You can perform some of the experiments you won't perform before and they could understand. And many others like in organic chemistry where you know you could have improvisation of the equipment.

Tatu concurred with Mbili in which he argued that the use of improvised materials in the teaching of chemistry in rural areas was made relevant to the students preparing for the national examinations through students notes provided by the teacher. The notes included diagrams of the set up of conventional apparatus used to perform experiments as covered in chemistry textbooks. Tatu said:

> Yeah in this case of improvisation especially during taking the notes, you have to give the students the conventional apparatus, a diagram of the conventional for the sake of exams. Of course this [will certainly] be making a teacher do double work but it is necessary.

On the other hand, the in-service educators found one aspect of the in-service teacher education system unattainable in their district. According to the educators, the cluster education was not significant in their district's professional development of teachers. Tatu put it:

> I think like in Simba here you see that the cluster centers, we finally had to eliminate them. Because we found it was not economical to run the cluster centers. We had to bring all the teachers to the district in-service unit. The funds we were collecting were not enough to run the clusters. Of course the organizers initially had thought that we could have cluster centers which could be closer to the teachers in their schools. I could say that is one aspect that did not work well. And maybe the other aspects that my colleagues can come up with but generally what I feel lacking…what we went through in the in-service "training" sessions, a lot of it was useful.

The cluster education sessions were found to be uneconomical to run, partly, because of the infrastructure of schools in those areas. The district in-service education kitty was not in a position to adequately support the cluster education session as they were originally envisaged by the SMASSE Project.

Changes made in planning and implementing chemistry unit lessons. The in-service educators observed that lesson planning and preparation was hectic in relation to the materials required for students' activities. But once the teachers had the required materials, the chemistry unit lessons were easily implemented. Moja said:

> …you know the planning, the planning when you are preparing for a lesson, it is supposed to, it is hectic because you have to look for really materials for the students' use in the activities. But once we have actually found this, it is now easier. It becomes easier for the teacher going into the class during the lesson than it has previously been.

Prior to the SMASSE project the educators had a different way of planning their lessons. They would think of the class activities as the lesson progressed and using students' responses, they made changes in class to cater for individual differences. As Tatu put it:

> …you know before SMASSE, we used to plan in the class but once the lesson has started and you don't have any plan that is when you come up with activities, that is when you open textbooks to get the [activities] and so on.

The SMASSE in-service education had made the educators to change their way of planning and implementing chemistry unit lesson plans. They had a new lesson plan format which the educators felt that was teacher friendly. They had to plan and identify the teaching and student activities early. The activities were logically organized to ensure that students had maximum learning opportunities during the chemistry sessions. Tatu said:

> But now from SMASSE we have seen that you have to do planning early, you have to identify the activities you are going to carry out as a teacher. You have also to identify the activities the students are going to carry out and how they are going to be carried out and look for the materials. And also organize in a logical way in which you are going to carry out these activities so that learning takes place. Then also you find that now in SMASSE, we managed to come up with a format of a lesson plan which makes the planning easy. Format we start for activity and teaching/learning points or teaching/learning notes and remarks. You see this format is teacher friendly. It makes the teacher really plan very easily rather than the old one which was lengthy.

Mbili added “because of this SMASSE…I have found it now difficult to go to class without, you know, at least having even if I don’t have that detailed planning, at least I have identified some activity that I will give to the students.”

The educators were able to make changes during their lesson planning and implementation. However, to some extent, they found lesson planning using the SMASSE format required considerable amount of time. However, once the lesson plan had been made, its implementation was teacher friendly. The students had activities to perform while the teacher assisted them in their learning processes. This was a big change for the teacher educators who used to teach using lecture method, gave student notes and class experiments depending on the availability of resources or teacher’s enthusiasm in having his/her students perform class experiments or have a teacher demonstration. In this regard, Moja said:

> You know when you don’t have activities for the students you find during the teaching of the lesson you are actually doing a lot of work. You find like I was cracking a joke last week a teacher came to the lab and he was still on chalk. That one is hands-off that meant that actually the students had no activities except to wait the writing on the board. So when you are preparing according to the SMASSE, in the preparation part it is not teacher friendly but when it comes to class now during the implementation of the lesson it is quite teacher friendly because much of the work is done by the students. So that is the much which has really assisted in preparing the lesson and disseminating the same knowledge in class.

Mbili concurred with Moja that following the SMASSE in-service education lesson plan format, their chemistry unit lesson preparations had become effective. The students enjoyed the chemistry sessions because they were involved in learning activities. As Mbili put it:

> …You know when it comes to the preparation, yes it is effective but when you go to class, you find that the students will [use] because you have already identified the activities and then at the same time, you know the students enjoy it. And the students they want you know sometimes learn this and you go to class and you don’t want to talk, talk, talk, you know you find that they are bored. So I think that is true....

However, Tatu was worried of those students who might not be doing the hands-on activities during the teacher demonstrations or group activities. He said:

> …I have come across one problem in carrying some of these activities because you find that if you have to use the students what I have [been] wondering is that these students who are participating in the activities you know they are not with the rest of the students to watch what you are doing. These ones you are using are they learning?

According to Mbili, Tatu's concern was not a problem because one can be choosing on different students during different lessons. Mbili said:

> …I think it is okay because when you use them at that time you know you are not using throughout you know that is one activity, then there you choose another group…And remember when you do something actually is when you remember it more. So these students are even more advantaged than the ones who are just looking on because these ones will remember exactly what they did.

Involvement of different students during the teacher demonstrations ensured that more students participated in conducting the experiments in class as opposed to them being spectators. Mbili had the teaching learning metaphor of "when you do something actually is when you remember it more."

Changes made on areas educators were not exposed to during the SMASSE in-service program. The educators were able to improvise teaching materials based on their district and individual schools' situations. They were able to improvise these materials without duplicating those covered during their national education programs. This showed that the educators were able to apply what they learned during the in-service courses to their local situations. This transfer of knowledge and skills was an indication that the educators were being prepared well to face the challenges of teaching chemistry in diverse situations in rural Kenya. On the changes the educators were able to make on improvisation, Tatu commented:

> You see on the part of improvisation this one will depend on your situation on the ground. You don't have to improvise exactly the way you did it in the SMASSE. It will depend on the materials available and also in carrying out some activities will depend on

> how large your class is or how small it is. It will also depend on what the weather is like on that day. So you have to change a lot of things depending on the circumstances.

Changes were also made in the evaluation form. At the national in-service education center, the participants had prepared a common evaluation form to be used by teachers during lesson evaluation. However, the educators were able to modify some sections of the evaluation form to suit their lesson assessment in their chemistry classes. This was a good indication that the educators were not copying what they were being taught but were able to apply the learned knowledge to their local situations. The students were able to provide feedback to the educators on specific areas covered in the lesson. The students' feedback was important to the teachers in enhancing subsequent chemistry unit lessons' implementation. On the modifications made on the lesson evaluation form, Moja said:

> And if I add also from the evaluation form, this we normally give out. I give the, mine I kept because there is a part which is, was the lesson interesting? [what] was the level [of] motivation? So mine I added here, which part of the lesson didn't you understand? Which part is that…? You specify. So that if it is the area of maybe where someone was drawing the bond, then he tells [me that] when I am joining the bond it is difficult to see which electrons are coming from here so that there is a covalent bond, something of that kind, so that I know the specificity of misunderstanding in the students. So their specifics, they write it down so that I can know this is the point. And even it comes a time when I have gone through the topic I can also ask then now that we have completed this topic what have you not understood here? That one I can take my extra time and even go to teach the students in the evening or at night.

Tatu concurred with Moja that it was better for a teacher "to be specific not just to follow the conventional way of making evaluations." He remembered one time when he asked the students "which part of the lesson they enjoyed and which part they did not enjoy." He used the students' feedback to reinforce the areas they enjoyed learning, while he had to improve on areas they found difficulties in subsequent lessons. Tatu commented:

> You know once you know the part of the lesson they enjoy then next time you would reinforce that because you know that is what they enjoy then you pronounce it more so that they can gain more there. Then also the areas they didn't enjoy once you know them,

> [and] then you know how to handle them next time. Like if some students told me that in their group they failed to carry out the part I had given them and then the way I did not get annoyed, the way I did not punish them for not succeeding in that aspect that they liked that one.

On the other hand, Mbili sometimes was not able to have the printed evaluations forms to use in class during chemistry sessions. She had to use plain papers in which students gave open ended feedback on the areas of the lesson they enjoyed and the areas they wanted the teacher to improve on or had to address in subsequent lessons. Mbili commented that:

> ...on the part of these evaluation sheets, sometimes I have found it also difficult to get the evaluation forms. So what I do sometimes I just give them plain papers and ask them to be okay and write everything even including me as a teacher you know, you know what they don't like about my teaching and something like that.

There were changes made when giving activity instructions to students to accommodate the shortage of stationery in schools. In many situations, it was not possible to have printed materials on student activities. The teachers wrote the instructions for the students' activities on the board. The students had to copy the instructions in their notebooks during the lesson. However, it is worth noting that this was the way many schools with inadequate resources for science subjects had to cover teacher demonstration or class experiments. The teacher had to go to the laboratory early to write the instructions on the board for the students to copy when the classes started. Sometimes the teacher wrote the instructions on the board as the lesson progressed. On students' worksheets, Mbili said:

> …in fact I was saying the other thing we learned in SMASSE that I don't really use is the students' worksheets. And at the work, the students' worksheets are good because that is where we give student activities but for example in a school where I am even typing those worksheets is very hard because there is only one typist who is doing everything. So you find typing let's say, you know, the papers for producing those worksheets is also very difficult. So instead of using the students' worksheets sometimes now I have turned to, you know, to writing the activities on the board and have them copy because I cannot produce the worksheets.

However, some schools were well endowed with resources for effective chemistry teaching. On the provision of chemistry materials in schools and in reference to other schools which had inadequate resources for teaching chemistry, Moja commented:

> It is unfortunate that you don't have some things. In my school the materials' production is the easiest. But it is another situation which normally you can do. Once you have prepared you can give the students to copy during their free time so that the next time you are going to class you find they already have the worksheet in their exercise books that now is easier that way so that they copy maybe during preps, now I think we are all in boarding schools. So they can copy at night and then the following day when you are going to class you find everything is ready there for you. So you go over it. Anybody who maybe has copied something wrongly can rectify.

Moja had no problem of producing any written materials for his students. His school was also the district SMASSE in-service education center. It had almost all teaching/learning facilities to be found in a modern well equipped secondary school.

Planning and implementing chemistry unit lessons. Tatu started off arguing that these topics were different and for one to make sure that he/she had covered the content of each topic effectively one must use appropriate teaching and learning approaches. The participants designed and implemented unit lessons on the periodic table, "mole concept", electrochemistry, and organic chemistry. It appeared that the participants had improved their teaching practices on each of the chemistry unit they were in-serviced in. Following are the participants' experiences on the chemistry units they taught.

Planning and implementing lessons on the Periodic Table. The educators believed that the topic on the periodic table was the core of chemistry. The learners need to understand the periodic table first before they proceed into other chemistry areas that involve chemical reactions. According to the in-service educators, students who do not understand the periodic table well were likely to have difficulties when studying other topic areas in chemistry. For effective understanding of the periodic table by students, teachers should cover valences first followed by chemical formulae of compounds and then the chemical equations. Teachers have to plan for student activities when covering these areas. On the teaching of the periodic table, Tatu noted:

> It is very important to cover this topic of periodic table thoroughly for actually is the core of chemistry. It is in this topic we cover the valences and then later we cover about the formulae of compounds and then later also with chemical equations. Now once these areas are not well covered then the other areas of chemistry, the other topics become very difficult. So it is good to build [among] the way we have [inaudible] we used to make it concrete to have activities that students could participate in to enhance their understanding.

Mbili supported Tatu's assertion on how the periodic table can be presented to students in school. As Mbili put it:

> ...something to add, especially, when you come to the valences, as he has said you know now you have done the periodic table and they have known the rows, the groups and as he said if you can use the colors I think it will help them. And so now they have known but maybe the valence and the number of the outermost electrons will be the same.

However, the students were found to have difficulties in writing the chemical formulae of ions. Mbili felt that students can be helped through use of improvised models of the electronic configurations of atoms and ions. By so doing, the learners are able to visualize and understand how positive and negative ions are formed, and why various ions have different ionic formulae. On how to assist student know how to write ionic formulae, Mbili said:

> Now sometimes I find it difficult for a student especially to write the formula of an ion. Now sometimes the students do not understand that the protons do not take part in the reaction involving electrons. So like that one maybe you could have some model of electronic configuration and then you can have a wire and then you can pick "Plastocene" standing for electrons and then you can have a number at the center standing for protons. And so during the ion formation, you know you can decide now this one had so many, magnesium, two, then you can decide to remove the two electrons then the students will count now the electrons left to see they are ten, then the protons are the same. Then from there you can come and tell the students because it has more positives now than the negatives this is how you can write it. And then you can go to the other one and I think it helps because they are seeing it. They are seeing it you have removed electrons. I think I find it helping the students quite a lot and you know naturally the students like where there are those activities you find that they are moved.

Moja concurred with his colleagues on how the periodic table can be taught and how improvised models help students to understand the topic better. According to Moja, the students must first understand the atomic structure in relation to electron arrangement in atoms. Good knowledge about the atomic structure and electronic configuration in atoms helps students to understand why various elements are put in given groups and periods of the periodic table. In supporting Mbili's use of improvised materials to teach the periodic table, Moja said:

> …what you have used as those wires that is what we have used most of the time and you know for you to come to the periods and groups, first of all the students must understand the arrangement of electrons in an atom. So emphasis here like in my case before I start teaching the periodic table I must emphasize on the atomic structure. So like these first twenty elements they must use those wires and then see the arrangement of the electrons because now when you will be talking about the groups in fact they will be knowing because they will just count and see how many electrons are out there, three group three, if they are looking at the periods they just count the energy levels and they know which period this one belongs. That is more or less of what is most probable to use in teaching of periodic table.

Tatu argued, further, that when teaching the periodic table one had to bring out the trends and patterns in the properties of the elements. One has to plan for teaching and learning activities that will cover the trends and patterns in properties of elements very well. One way of doing this is to prepare adequate periodic table charts suitable for each lesson being taught. The prepared charts ought to be prepared in a way that all students are able to view them in class. They have to be visible and readable by all students seated in class. On how to plan an implement lessons involving the periodic table, Tatu said:

> ...like the periodic table, of course here what one has to bring out is the trend and the patterns in the properties of the elements. So here then one has to bear in mind the activities that the teacher has to carry out and those the students will carry out in order to bring out these trends and patterns in their properties of the elements. So then here like you must have a chart of the periodic, one must prepare enough charts and which can be seen from far.

The educators believed that appropriate use of charts in teaching the periodic table can be reinforced through use of other teaching aids such as pointers to show the parts of the periodic table that the teacher/students were discussing or what the teacher wanted to be highlighted. By so doing, the students are able to follow the teacher's plan of action as he/she covered the periodic table. Tatu commented, "…and if the periodic tables are available, they should be appropriately hanged where they can be seen and something like a ruler or a stick must be availed to use in pointing out the elements and something like that."

Use of letters to represent the actual elements in the periodic table was found to be appropriate in allowing students to follow and understand the chemistry behind the periodic table. The use of letters helped the students to avoid cramming the properties of the individual elements in the various groups and periods of the periodic table. According to the educators, this approach greatly assisted the students in understanding the chemical concepts because they viewed the periodic table to be the core of chemistry. This approach made the students to be able to answer any questions on the periodic table because they were able to relate the periodic table with the chemical reactions they covered in chemistry classes. In this regard, Tatu said:

> For this topic of the periodic [table], I find it very appropriate in most times to use letters to stand for the elements. Of course you can provide the atomic numbers but now you use letters. Probably you use the actual names of the students in asking them let's say some questions about the elements. Once you use the actual names of the elements, then even without using the structures and any other atomic properties of the elements, the students are able to come up with the answers.

Lesson plan preparation and implementation on the periodic table can be strengthened by having the teachers being more innovative in their teaching approaches and strategies. Teachers can use different colors to show the patterns and families in the periodic table. The different colors are likely to assist the students when they learn various groups such as metals, non-metals, transition metals, gases, halogens, noble gases, alkalis, and alkaline earth metals. Tatu said:

> ....Like the periodic table you see one way of really bringing out in a very colorful way, elements like you can have the metals having a different color in a chart, the non metals different color, transition elements different color or you can give the different families different colors. Alkaline metals different color, alkaline earth metals a different color, halogens a different color, noble gases a different color and that one will enhance the understanding of the students.

Chemistry lessons on the periodic table can be improved by having a plan on how to evaluate the teaching learning sessions. As Tatu put it:

> Then also a suitable way of evaluating the lesson must be found... So I recommend very much like when we are testing the periodic table we use letters to stand for the elements: x, y, z, a, b, c, d so they are not able to know the actual element but they are able to use the atomic properties now to come up with their properties and other things about the elements.

Lesson evaluation is an important component in teachers' lesson planning and implementation, as continuous and appropriate lesson assessments help the teachers to improve on subsequent lessons on the Periodic Table. From the discussions, it was evident that the participants believed that the Periodic Table was the core of chemistry. When handling this topic, the participants felt that a teacher has to cover first the elements' valences, secondly cover the formulae of compounds, and thirdly the chemical compounds. The participants made their periodic table lessons concrete using student activities. Students need to be thoroughly prepared in this area in order for them to understand the chemistry of various elements. This requires appropriate teaching and learning approaches in schools. Teachers ought to think about teaching/learning activities in the trends and patterns in the element properties. Teachers have to prepare charts or/and have conventional charts appropriately hanged in class. When teaching the periodic table using charts, the teacher should have a pointer to highlight the parts of the periodic table being addressed.

According to the participants, teachers ought to plan for lesson evaluation in advance as they prepare to teach the periodic table. Continuous feedback during lesson implementation helps the teacher to know his or her students level of understanding and which students need more attention in given areas that are being taught. The participants found it appropriate to use letters to represent elements when teaching the periodic table. Use of letters to represent the elements made the students to comprehend the chemistry behind the periodic table rather than cramming the elements' chemical facts. The teachers used question answer techniques to cover work on the periodic table. They also used different colors for different family patterns/elements, for example, metals/non metals, transition elements, alkali, alkaline earth metals, and halogens. The participants made the topic understandable to the students by using models, which were either conventional or improvised.

Planning and implementing lessons on the "mole concept". The participants felt that the topic on the "mole concept" scares students, right from the start. However, the participants were able to address the students' fears by not telling them that they were starting the topic on the "mole". The students come to learn later that they are studying the "mole concept" as they discuss basic units in their daily life such as a dozen, then relate to the "mole" as a quantity of material equal to $6.0X\ 10^{23}$ particles. On how to introduce the topic of the "mole concept", Mbili said:

> Now this topic, the "mole concept", scares students right away I don't know for what reasons. But any time you know they know they are going to start the "mole concept" you find really, you know they are scared. So personally what I have done when I am starting the topic of "mole concept", I don't even tell them that we are starting the topic of the "mole concept". They come to learn much that we are now doing the "mole concept". So naturally or usually when I start that I start by just giving them we discuss the unit you know the basic units that are used every day and then you if it is a dozen, twelve items. If it is a pound these many items when you are talking about Kenya pound shillings. Then you say now we have a number here this and this and this, then you say because of this number it is the unit, the unit is the "mole". And there you know [inaudible] these are ones, ah the "mole" we are starting the "mole" and then from there they take it positively. But you know usually I used to start when I am starting the "mole" I just go to class and tell them **today we are doing the topic of the "mole"**, "mole concept". Ah, once you write it like that the students fall off. So that is how I start it.

The participants concurred that the “mole concept” was very important in volumetric analysis experiments on titration. Many experiments have to be done to enhance student understanding of the “mole concept”. According to the participants, students ought to perform an experiment at least every week and calculation activities given to reinforce students' understanding of the “mole concept” in titrations, for example, converting a given mass into moles. Tatu commented:

> Of course in the “mole concept” is where we get the necessary information to carry out volumetric analysis experiments on titration and so on whereby they are able to count the particles are in a large scale. I think here to enhance the student understanding you have to carry out a number of practicals. So there must be enough experiments therefore the students to carry out starting with simple ones and to the more difficult ones. And the experiments should be carried at least every week. We should not carry them out only at that time we are starting the mole, let's say at the beginning of Form three, then after that we stop completely and end up meeting them in the exams. So to remind them about the concepts covered in this topic, the “mole concept”, there must be at least an experiment in a fortnight at least one.

Practice questions also assist the students to know how to apply the “mole concept” to particles involved in chemistry such as atoms, molecules, and ions. When students are assisted to master calculations involving the “mole”, they enjoy participating in experimental work on titrations and easily solve advanced “mole concept” problems. As Moja put it:

> ..In my case I really find it the activity I normally give here mostly goes with calculations where from the “mole” for the students to do very well in titration, they must understand what a “mole” is. And for example can they convert a given mass into a number of “moles”. If they can not convert the number of given grams into “moles”, then even if they were given the titration it becomes extremely difficult for them.

The educators had found one of the recommended secondary school textbooks quite relevant in preparing their students on calculations on the “mole concept”. The said textbook had a variety of “mole concept” problems that helped students understand the topic well and how it was applicable in their everyday life situations. As Moja said:

> So here I have specifically emphasized the use of Patel book three (referring to a Form three chemistry textbook written by Patel which is used as one of the secondary school chemistry-class textbooks in Kenya. The textbook has many practice questions on the "mole concept") with all those problems they have so that the students can see a mole when it is the mass that is in grams. If I say four grams of sodium hydroxide, the students should be able to convert that quickly to number of "moles". If I asked them how many sodium ions will be there in four grams of sodium hydroxide, they should be able to convert that.

Student activities were emphasized in the participants' "mole concept" classes before they embarked on practical sessions on titrations. Students' prior knowledge on how to convert a certain masses of particles of a given substance into "moles" and vice versa was a pre-requisite to the titrations problems they had to solve during practical sessions. The students were made to understand that a "mole", as a unit of measurement, was a very large unit that we don't even have a "mole" of people on earth but it was possible for small particles found on earth. Moja said:

> So that part which is basically having activities in the form of calculations is where I emphasize so much before I go to giving them a lot of practicals now on titration. And there is also one joke which I normally have when I am looking at the "mole" and Avogadro's, you know you sometimes wonder whether the word has one "mole" of people (laughter). If the world can not produce even a "mole" of people, the whole world because that Avogadro's number, you know, is so big that the world can not have a mole of people.

The students were guided to understand how a "mole" was applicable to various particles covered in chemistry such as the electrons, atoms, molecules and ions. They had to know the relationship between the Avogadro's number and the "mole" of particles under review. In Moja's words:

> So I normally make them understand that when we are talking of a "mole", it should be a "mole" of any substance so that they don't expect that if I calculated a "mole" of ions, then when it becomes to "mole" of molecules it will not be a "mole". So they know that anything that can give out Avogadro's number of particles should be referred to us a "mole". So here the calculations are **very, very** important as the activities. And they must be followed and be given in a plenty of them for the students to understand.

The teaching of the “mole concept” was being simplified through use of films and videos on reactions involving the “mole concept”. According to Tatu:

> There are these films that are available like from SMASSE, like the film on the “mole concept”. We are able to weigh a “mole” of ions, atoms and they are able to see that that is a “mole”, Avogadro’s number of atoms or ions. If you have the facilities we can also show them the films on the “mole concept”.

From the participants’ discussions, it was evident that students benefited from the “mole concept” lessons that were introduced based on the students’ practical experiences and the volumetric analysis experiments on titrations. The students understood the “mole concept” better when they are given opportunities to solve “mole concept” questions in class or as assignments. From the observed class sessions on the “mole concept”, it was evident that the students’ work was reinforced by the continuous lesson evaluations the teachers had adopted as a result of the SMASSE in-service education courses.

Planning and implementing lessons on electrochemistry. When teaching this topic, the participants organized activities to show movement of ions. However, teachers had a problem of which experiments to conduct on movement of ions, that is, should there be a class experiment or teacher demonstration? The participants planned for experiments that involved colored electrolytes or formation of colored products. According to the participants, there must be suitable electrolytes to reinforce learned concepts, for example, passing an electric current through molten substances and then using a salt bridge that melts easily such as potassium bromide, which produces a brown gas at the anode and silvery lead at the cathode. Tatu said:

> Yeah the other topic electrochemistry, this one we have to organize activities to show the movement of ions, movement of ions so that they understand what the electrochemistry is about. You see in a number of cases the problem is which experiments must we carry out here. And how should we carry them out, as class experiment or demonstration? Now here it will depend on the circumstances but as much as possible we should use like the electrolytes that are colored or be produced, eh products which are colored. And also they must be suitable electrolytes. You see like if you want to pass electric current through a

> molten substance, here you should choose let's say a salt which melts easily like the lead bromide. And like that when it melts then you are electrolyzing it like at the anode you will have bromine, a brown gas, you see brown. At the cathode you see the silvery lead. So here we must choose suitable electrolytes that bring out the concepts.

The participants were able to improvise electrolytic cells (voltmeters) using locally available materials such as transparent containers that help students to observe changes taking place in them. In cases where electricity was not available in school, the participants used dry cells or accumulators as sources of electric current. Tatu, further, continued to comment:

> Now there are also voltmeters that are electrolytic cells that we can improvise. We can use carbon rod and plastic containers that are transparent and then you carry out electrolysis in those apparatus the students are able to see what is happening. Now if we don't have to go for electricity from the mains we can use cells or accumulators as sources of electric current.

When conducting lessons on this topic, the participants' students did calculations that involved the first and second Faraday's laws of electrolysis. According to Tatu:

> Then I think just like in the "mole concept" also in electrochemistry there are some calculations, those ones on faraday's laws of electrolysis, first law and second law. We must give them plenty of those calculations and also emphasize the applications of electrochemistry like the cells, accumulators and so on.

The participants concurred that redox reactions were a pre-requisite to students' understanding of electrochemistry. The redox reactions involve movement of ions that are covered in electrochemistry. Moja said:

> …when we are talking about electrochemistry, specifically, the students must understand, it is something to do with redox reactions. So as you are starting this topic a teacher must emphasize that a redox reaction there must be movement of electrons from one species to another. This is where you will find maybe will take let's say you take iron fillings then you drop them in copper (II) sulfate (solution), you will see that the solution becomes pale green as the brown deposit of copper. So in this redox reaction there must be movement of those ions.

The participants felt that the students should be let to understand the difference between electrolytic cells (produces electric current) and voltaic cells (electric current producing redox reactions) immediately after introducing chemistry. This makes it easy for the students to follow and understand concepts in electrochemistry. As Moja continued to put it:

> So coming to the activities you give immediately we are introducing electrochemistry, there are two things you must be specific about electrolytic and voltaic cells. So the students must actually differentiate between the two. One produces electric current, one is electric current producing a redox reaction. So in these voltaic cells it is actually redox reactions [and] that is why in the introduction you must have mentioned redox reaction. So and they must do it. So once they have done it, it is very easy.

There was a belief that the topic on electrochemistry had many very good activities for the students to perform. Improvisation of materials when teaching this topic area was possible, especially in the rural schools which were likely to have inadequate conventional materials for electrochemistry. The teachers can improvise single cells with a salt bridge and perform hands-on activities on processes such as electroplating. In this regard, Moja said:

> Improvisation in even having this single cell with a salt bridge, you know it is very easy. These days we don't have to go for a salt bridge where maybe we are going to use a U-tube, just use any absorbent material like tissue paper, the serviette, anything that you can soak in potassium nitrate solution and then there you are. So that part of electrochemistry, I don't think it is really difficult even in application of electrolysis like I said about electroplating. We normally take even something like, I ask the students actually to give me their keys. Once they give me the key, I just connect it; put it in copper (II) sulfate solution and the key will become brown. So it changes and it takes only seconds. So you can imagine when the students have used their keys and going with them to the dorm how they will always be remembering, how the application of electrolysis. So I think this is one topic which I think which has got very good activities that can be given to students.

From the classroom observations and tour of the school laboratories, it was evident that the teachers were improvising apparatus using the locally available materials. Following the in-service education programs in chemistry, the teachers were also able to perform improvised experiments to demonstrate movement of ions in chemical reactions to their rural school students.

Planning and implementing lessons on organic chemistry. The participants observed that organic chemistry had many applications such as the manufacture of clothes, medicine, plastics, and useful chemicals. According to them, it is important for a teacher to organize the topic introduction well, for example, by showing the students some organic materials found within their school. This provides students with a stimulating introduction to capture their thoughts. On the topic of organic chemistry, Tatu commented:

> Actually this is a topic which has a lot of applications, especially nowadays. The way of plastic materials we have, clothing materials, medicine and other useful chemicals. Now here I think if a teacher organizes the introduction well can really capture the students' interests. Like one way I would propose is the teacher to come to class with organic materials, plastics of different colors and what have you, the pens, actually the materials they have like their sweaters and so on. Once you give a very stimulating introduction, then you will be able to capture the students' thoughts.

The teachers can also give examples of locally available materials or processes. Moja, who concurred with Tatu, suggested that a teacher can even go to class with a local brew called "chang'aa". Although this brew prepared by the people in the rural areas has never been legalized in Kenya since the colonial times, the organic processes involved are very important for the students to know. Many of the students in the rural areas know how this traditional whisky is manufactured in their homes or at their relatives' homes. Covering the local processes were likely to make the organic chemistry more relevant to the students, many of whom are born, brought up and will continue to live in their rural areas. Moja said:

> So if you are talking about plastics and even when we are talking about distillation they will even…they are the ones to tell you how "chang'aa" is actually prepared at home because this thing happens in their home. So they will tell you about ethanol very well without you even going, you only go deeper because there (the one) they prepare at home can not be a hundred per cent [pure]. So you tell them now where your parents reach with this one then industrially this is the extra mile that the industry takes to get absolute ethanol.

On the experiences of using organic compounds manufactured in the rural villages in the secondary school organic chemistry classes, Tatu added:

> Yeah even "chang'aa". In fact I remember I was extracting indicators from flowers…because I was new in the school I could not trace where the ethanol was in the

> lab. I gave some students ten shillings and within very few minutes they brought me "chang'aa" but I tried to pour away the one that remained so that…you don't drink it.

The participants thought that they did not have any problem in planning for organic chemistry activities following their in-service programs. Teachers were able to use organic waste materials found within the schools' communities to strengthen the teaching and learning of organic chemistry. They were able to relate school science with students' practical experiences on preparation of organic chemicals found in their homes. As Moja put it:

> In fact organic chemistry has no problems as far as activities are concerned because even when you are trying to find the boiling points where the difference why the water has very high points, others some organic substances don't have [these things]. I drop something on their skin and then they can feel **very cold** and then all of a sudden it becomes warm. So these ones I think we have even like he has talked about plastics even these polythene papers, the students always buy bread so they have this. So in terms of materials I don't think we have a problem. And even when we are talking of thermoplastics and this other one, just give them those polythene papers they will heat and start dropping you know.

The participants were able to have prior lesson planning and resource mobilization unlike in the past when they collected organic materials as they prepared a lesson. They taught organic chemistry using conventional or improvised models on organic structures. Mbili said:

> Yeah here maybe we should take our time in planning collecting those materials not to wait until the time when we are teaching. I think earlier we collect the materials and even tell the students to come with them and also use models to demonstrate the organic structures. Like we can use Sodom apple as atoms and join them with thorns and the students will be able to build up those structures.

On the use of locally available materials to make models of organic compounds, Moja concurred with Mbili and added, "you can use beans and maize. Beans and maize do very well" when making model structures of compounds. Tatu agreed with his colleagues as he said that one can also use "clay or mud, you can mould the mud like that when making models of organic compounds structures." However, the in-service educators felt that students had difficulties studying organic compounds (such as alcohols, polymers, and carboxylic acids) and their nomenclature. There should be more exercises and activities, especially on preparation of esters and soaps. Tatu observed that:

> …I have a problem in the past that I find for some students they are not able to understand any organic chemistry beyond the hydrocarbons. We cover alkanes, alkenes, alkynes, that is the far they can go. When you now try to proceed with the alcohols, carboxylic acids and polymers, there I don't know what we can do in that case.

Moja concurred with Tatu's assertion that the subtopic areas of alcohols, carboxylic acids and polymers were sometimes difficult to many students. The nomenclature of these organic compounds was a bother to students, perhaps as a result of the chemical and structural formulae involved. The more carbon atoms an organic compound has the more isomers it was likely to have, which have different names. One way the participants addressed this problem is by relating the organic chemistry to the materials that students come across in their local communities. Moja said:

> …and the problem I think basically is nomenclature but if you went and you were teaching for example alcohols and use what they normally see like what I talking about "chang'aa" and you were talking about now industrial production of ethanol. You tell them the "chang'aa" is the…the students can describe very well how their parents take starch and then I don't know they add some water and keep it for three days or so, add the yeast and so on and so forth. So that one they will find difficulties in nomenclature, the naming of those others, like alcohols. I think there is where the problem basically is in the naming but with more practice and follow up, it can always be overcome.

The in-service educators argued that more emphasize should also be put on group activities because students motivate each other when they work in groups as opposed to individual activities. They all agreed that teaching organic chemistry required use of "more activities, and preparation of esters when teaching alcohols so that the students are able to "smell it, and bring also to class some sweet smelling flowers for them to compare with." Students can be made to discuss the manufacture of organic compounds such "cutex" and soaps they are familiar with. Mbili argued that it was most likely that "the students will make soap and then they will wash with it' in the laboratory and they will be able to understand how the soaps they use at home are manufactured. Agreeing with Tatu on the importance of having more activities for the students, Mbili put it:

> Actually it requires, as you have said, a lot of exercises when it comes especially I find them you know at the beginning you find that they are sort of getting excited but as you go on as Mr. Tatu said that you go on you come to alkanoic acids. And then you find that now they think the work is becoming tough.

Tatu argued against teachers putting more emphasis on individual activities. He said, "and maybe let us not [over]-emphasize individual activities, like you tell them now here is the molecular formula, draw the structure alone. Let them work in groups." As Moja and Mbili agreed with Tatu, they argued that group work made their students to "motivate each other" and especially if they were given "an activity of making the [carbon-hydrogen bonds]" in organic compounds.

The teaching and learning of organic chemistry is made simpler, like in the "mole concept", when teachers use films and videos on large scale processes such as distillation of petroleum. According to Tatu:

> There are these films that are available like from SMASSE…If you have the facilities we can also show them the films on the…organic chemistry they will be able to see the large scale distillation let's say petroleum and so on. You see of course like ethanol we have the [gasoline] in the petrol station. Some students don't know that it is there they can visit the places and be given a little to smell. Now also when we use these films or videos they maybe able to see things they might have not come across.

Well planned class excursions to petrol (gasoline) stations and (oxyacetylene) welding places enhance the teaching and learning of organic chemistry in schools. In Moja's words:

> …it is like when you are teaching Form twos and you are talking of oxyacetylene. You know the students will think that this is something difficult which occurs somewhere, you only need to bring them to "Daraja Mbili" (referring to one of the places in Simba town where welding is done) here where there are people welding and then you are up again and there they are. And you can see even those who even didn't go to school can still use the oxyacetylene flame.

It was the participants' feelings that chemistry should be made compulsory only up to junior levels and optional at higher levels. In this regard, Tatu commented:

> …this is where I was thinking about the KJSE (referring to previously done national examination at Form two levels, for schools that were managed by local communities. The schools were being referred to as "harambee" schools. The examinations were known as the Kenya Junior Secondary Education Examinations). Some students can do chemistry only to KJSE level, Form two there and not beyond.

In Kenya, chemistry is compulsory in all public schools and is taught in all classes in high school in every week of a school term. Perhaps making chemistry optional in grades 11 and 12 might reduce the cost of implementing chemistry curricula in Kenya's public schools and have only those students interested in continuing chemistry oriented-careers to pursue advanced chemistry. It is worthy noting that the national chemistry examinations consist of two theory papers and one practical paper. All candidates must sit for all the papers and for one to be awarded at least a credit pass in the examinations; he/she must pass the practical paper. The practical papers are expensive to administer as schools must provide the chemicals and equipment specified by the examinations council.

The participants' views about the other topics they taught. The participants discussed other topic areas they taught in school following the SMASSE in-service education programs. The participants were able to apply their advanced teaching skills gained from the in-service programs in teaching the energy changes in reactions and the preparation of salts. The participants' experience in teaching the topic on the energy changes is presented first.

Participants' views on energy levels. The participants found the SMASSE in-service education very useful when conducting experiments on exothermic and endothermic reactions (such as molar heats of neutralization, combustion and displacement). For instance, Mbili gave her students exothermic and endothermic reaction experiments to perform in school. This way the students were able to observe the rise or fall in temperature in the experiments they performed thus making them understand the concepts involved. In this regard, Mbili said:

> Now about other topics let's talk about let's say energy changes in physical and chemical properties. Now some of the activities one needs to take in mind when planning in this topic what I usually do is for example now when I am talking about exothermic and endothermic reactions. I usually let them carry out an experiment where one is endothermic let's say dissolving sodium hydroxide [inaudible] potassium nitrate, then exothermic sodium hydroxide. So they will see that in one of them there is a temperature fall and in the other one there is a temperature rise then from there the explanation of endothermic and exothermic reactions.

The participants found that students had difficulties solving calculation problems involving the molar heats of reactions. To address this problem, the participants involved their students in solving problems on exothermic and endothermic reactions. In these exercises, the students were made to solve problems involving the molar heats of reactions. These activities made the students active and were important in helping them to have further practice in interpreting experimental data and making reports based on scientific evidence. On the student activities, Mbili added:

> There are also other activities like when it comes to the molar heat because there are also quite a number of activities that can be carried out like molar heat of neutralization, molar heat of displacement and there is also this other one about heat of combustion of fuel. One can also carry out that experiment. So usually I find once they have done these experiments there is also this activity of interpreting the data that is in the calculations. I don't know what my colleagues find out but initially you know it depends on what students you are dealing with. Initially I find they have a problem when it comes to the calculations, you know molar heat, so they will first of all begin by using if you say use ten grams, that is the much they use, but otherwise I think there you [will] be rich in activities and it makes the students quite active.

Tatu argued, further, that they assisted students in solving mathematical chemistry problems by relating them to the simple proportions topic that the students covered in mathematics. Tatu had said:

> ...a number of these calculations in chemistry if you look at them critically there is no any difficult mathematics. It is just simple proportion like if you dissolve this mass of

> chemical in water so much heat is evolved. If you dissolved a larger mass proportionally more heat will be evolved. So it is important to bring out that idea of proportionality.

By using the proportionality concept, the students were able to solve problems on molar heats of reaction.

Participants' views on other topic areas. The participants gave their experiences in teaching other subject areas and how the students can be assisted to understand the chemical concepts involved in the topics under study. On the activities a teacher can carry out when teaching sulfur and its compounds, Tatu said:

> ...Now coming to the other topics like the elements that they learn about in Form three, there are some activities we can carry to motivate the students. Like when we are talking about sulfur and [the students] may wonder about the smell of sulfur, you can tell them to rub their skin just like that and smell; they get the smell of sulfur.

On the other hand, Moja would go to their school dispensary to collect an ointment containing sulfur for the students to smell, in cases when sulfur was not available in the school laboratory. Moja commented, "what I usually do, I go to the dispensary, I bring this [ointment] they use, so I bring the ointment and then 'wanajipaka' (they rub it on themselves)."

In the rural areas, use charcoal for heating purposes. It is this charcoal that Tatu took to class to show to the students when discussing the various forms of carbon. In Tatu's words, "for carbon I bring charcoal, they have seen charcoal." Use of substances that students are familiar with were likely to make the topic interesting and understandable as the students made sense of the chemical concepts involved in the topic. Local examples were found to be very important when teaching chemistry in the rural areas of Kenya. The educators used to demonstrate chemical concepts and their application by using the common substances the students come into contact in their rural homes. For instance, when Tatu taught the topic on chlorine and its compounds, he had to consider some substances that contained chlorine the students were familiar with. Tatu said:

> Coming to chlorine, sometimes there is excess chlorine in the water, they get the smell or "jik" (referring to a washing detergent) and so on. Most of these chemicals we have them with us and if we can just draw the students' attention to them, then they are able to learn a lot of chemistry.

There were other areas that were difficult to have class experiments or teacher demonstrations. In these topics, according to Mbili who concurred with Moja, "the major activity here is just a discussion." The discussions were in line with SMASSE's focus on minds-on activities in chemistry lessons. On the difficulties faced by teachers and how to handle the topic on radioactivity, Tatu put it:

> Of course an area I find difficult used to be radioactivity. I don't know whether we have radioactive substances in schools and like in Kenya here we don't have nuclear reactors maybe we can show them pictures and also tell them about cancer treatment, radiotherapy. So there is some radioactivity like in Kenya in the hospitals if it is not available in nuclear reactors which we don't have there.

In addition to the class discussions on radioactivity, Moja felt that the students should be involved in balancing nuclear equations as class activities. When teaching radioactivity, Moja observed that:

> ...a discussion and then also you can involve them in balancing nuclear equations. I think this is also and area where we find that they are able to come across different reactions. Normally the reactions they know about in chemistry is about electron transfer. But in the case of radioactivity now here they have reactions taking place in the nucleus.

From the participants' responses, it seemed the teaching of radioactivity involved new types of reactions and chemical equations, which teachers had to make clear to the students.

Constraints in implementing SMASSE's ASEI movement and PDSI approach in schools. Although the participants had enhanced their teaching skills, lack of finances to provide adequate teaching/learning materials hindered their teaching of chemistry in the rural schools. The situation became worse in places where some principals were uncooperative towards SMASSE activities because they felt that the chemistry activities were becoming rather expensive for the schools to implement. The school heads and participants' colleagues still preferred traditional methods of teaching chemistry to that advocated for by the in-service programs.

The frequent curriculum reviews required new textbooks, while many teachers practiced examination-oriented teaching. The teachers' rewards in Kenya were more based on the examinations' results than anything else. The in-serviced teachers had difficulties teaching chemistry based on the new approaches because students were not interested in investigation activities that were not tested in the national examinations. It was also difficulty for the participants to continue using improvised materials whose application was not tested in the national examinations. However, teachers who used improvised materials were forced either to show the students the conventional apparatus or draw diagrams of the setup of the conventional apparatus during an experiment.

The district in-service resource centers had helped many schools which lacked apparatus or chemicals to borrow them. However, teachers' laxity to return the borrowed items to the district in-service education center inconvenienced others who wanted to borrow them for their schools. There was need for the SMASSE national office personnel to support the formation of district chemistry associations for the teachers to exchange ideas applicable to their school situations. This was likely to lead to proper management of district SMASSE funds to facilitate adequate provision of chemistry teaching materials in schools.

The SMASSE In-service Education Project: Issues for Consideration. The participants had benefited from the project in many ways. However, they felt that the SMASSE project planners and administrators ought to shift their focus from the number of those in-serviced to that of the quality of in-service being offered. Tatu said:

> Maybe what I would say after participating in this project, here I will call upon those who are involved in organizing and implementing the project not to emphasize on the numbers that they have "trained" but the quality of "training" that they are giving the participants.

Those undergoing the in-service program ought to see the direct benefit of the courses taken. As it was the case, there was no added advantage for those who were involved as the district in-service educators for five years to those who even did not attend the SMASSE In-service education programs. According to Mbili, teachers ought to be recognized following an in-service education program because "you are rendering services, so people must act." On teachers' benefits from an in-service program, Tatu said:

> And also maybe the participants will realize that they are benefiting directly from participating in the program. It is not just enough to tell a teacher that the fact that we are improving your skills that one is good for you. A teacher should see that there is some material benefit. After you have been improved so what?

The district in-service educators felt that it was a waste of resources for the project to in-service teachers who were not professional or who were not going to be prepared to become professional teachers. The SMASSE Project appeared to in-service all teachers in the districts but most of them were part-time unqualified teachers on vacation or waiting to join universities. By in-servicing these unqualified teachers, the majority of whom were not going to be professional teachers, was a waste of funds for the district which had set aside money to in-service its science teachers. As Moja put it:

> I was also thinking that...SMASSE should not "train" people who are short-lived in the profession of teaching like these pre-university students. They come and they give the "trainers" headache. And they are the people who normally cause a lot of havoc in the

> "training" centers because they know they are going. So you "train" somebody and in the next month he leaves and goes to take a different course in the university. Like these ones who have passed and they are going maybe to take B. Com, they are going to take medicine, they are going to take pharmacy, and here SMASSE is using a lot of funds to teach these people at the district level. It is very important that it only imparts this knowledge to the people employed specifically by the Teachers Service Commission. If there is a UT, that is "untrained" teacher, then I think there should be enough proof that this particular teacher is going to stay in the profession for a very long, long time than just one month or two months.

On the other hand, the SMASSE planners seemed to have forgotten to continue assisting the district in-service educators on the direction of the in-service programs after the pilot duration was over. The planners used the evaluation reports to recommend to the government to start SMASSE activities in all districts in Kenya. Although the Kenya Government started national in-service programs for science teachers, the pioneer districts had been forgotten all together. It was as if the districts no longer required the SMASSE in-service programs. An in-service program was only successful when it achieved its objectives and was sustained all-year round. It appeared as if this was not the case in the pilot districts. The planners had shifted their efforts to the implementation of in-service programs in those districts that had not had them during the piloting period. As Mbili put it:

> ...I think where we have reached now, like for example in our district, I think the SMASSE planners, that is the national "trainers", should come up and give us some direction because for example now we have the four cycles, what next? Are we going just to sit and forget all about SMASSE?

The situation worsened with the frequent transfers of many district education officials from the district. The frequent transfers of the district coordinators had impacted negatively on the sustainability of the in-service programs as those who joined the district education office were new to the project and took time to understand its mandate. Mbili observed, further, that:

> ...for example in our district there has been some changes in the D.E.O's office which means our coordinator is one of the people who have been transferred and so because of that we really don't know what we are supposed to do. As we were made to understand,

> we should be having “trainings" every year. So for example now this year we really don’t know whether we are “training” or we are not “training”. So has SMASSE now died in our district?

Guidelines as to how the SMASSE in-service programs were to continue in the district after the elapse of the piloting duration were important to ensure uniformity and compliance to the national standards and quality assurance. The directions were required because the district schools implemented a national curriculum and students had to sit for the national examinations. The situation was complicated because many of the teachers in-serviced had been transferred out of the district or gone for further studies, while new ones had been posted to the district. The district in-service educators, who were themselves classroom teachers, had no authority to decide on what should be done to those not yet in-serviced by the SMASSE project. In this regard, Mbili added:

> So I think the national [in-service education] Unit should come up and give some guidelines as to what we should do. Because as SMASSE, we feel we have “trained teachers. I think we have not “trained” teachers per cent of the science teachers we have in our district. Some of the teachers we “trained” have moved out and we have so many new teachers that have been employed. So what do we do? Many teachers actually who have been “trained” have moved out. Actually they are not here. Some of them have gone for further studies. So we have got a very small number. But then unless we are guided then it means that the SMASSE in our district has come to an end.

The participants also felt that the district education administrators were not giving the SMASSE in-service education the seriousness it deserved. The administrators were treating the in-service programs like any other school activity such as drama. The district in-service educators concurred that the district education administrators ought to grant in-service teacher education programs more priority as this had greater impact on many stakeholders. On the ministry’s officials’ role in the in-service education programs, Tatu said:

> ...you see also the Ministry of Education, like the D.E.O’s office, they have a lot of work. Now here you find that they are treating SMASSE, let’s say, as just any other activity like drama, [sports] but I think SMASSE is so important that it should not be treated just as

> any other activity. They should find a way of organizing better and sustaining it better than currently is. Otherwise it is a very useful project and if possible then the in-service should be institutionalized as soon as possible so that there is an independent body of the Ministry of Education in charge of in-service rather than attaching the in-service to the Ministry of Education and overworking them.

The district in-service educators felt that they were being sidelined by the administrators of the national in-service education unit. Despite their efforts to ensure that the in-service programs were implemented at the district level, the national in-service education unit officials appeared not to recognize these efforts. Non appreciation of the in-service educators' contributions in implementing the SMASSE programs in the districts demoralized those who wanted to make their contribution in in-service teacher education. In this context, Mbili put it:

> But let me complain about the national "training" particularly. I don't know whether I should say the head of that unit because I know like in our district we have our own problem and as much as I remember as a "trainer" we were trying very hard but you see it is like as if our effort never used to be recognized because anything coming up about districts you know like Simba would be one of the worst districts and there are some other districts of course I know they were not even performing, they were not even better than us. Like even when we finished all our three cycles some districts were even doing their first or second cycle but you know such a thing was not brought out. So the people were always pointing at some districts that were not performing and not others and yet we noted that those districts were not even performing. And you know this was demoralizing the "trainers" after all whatever we do you know nobody is noticing that we are trying our best.

The participants also felt that their district was given a low deal when it came to the in-service educators selected to be educated outside the country. According to the participants, their district was given a low deal as none of them was ever taken anywhere during the pilot project duration. In Mbili's words:

> I say like when it came to now getting people that were going to Japan, I think especially our district was given a very low deal. Yeah it was given a very low deal. Other districts you hear people are coming from here but look at our Simba, nobody benefited. So that makes our morale go down. So I think such things should be looked into.

Although the pilot project had come to an end in the pioneer districts, the lessons learnt from these district in-service educators are very important in the design and implementation of in-service teacher education projects. The project planners and administrators ought to recognize the educators' contributions and have the education opportunities fairly distributed among the participants. From the district under the study, it appeared as if the in-service educators' efforts in the in-service chemistry teacher education were not recognized fully by the project officials concerned.

Summary. Teaching of the periodic table was viewed as the core of chemistry education. When appropriate teaching approaches are used, students are able to better understand the trends and patterns in the periodic table. Thorough student preparation on valences and writing chemical formulae of compounds helps students to be able to balance chemical equations.

The "mole concept" was one of the topics that high students had most apprehensions. However through SMASSE in-service teacher education programs, the teachers were able to organize relevant activities based on students' every day experiences to enhance their understanding of the topic. Students should be given more practice in calculating "mole" related problems before they start titration experiments.

In electrochemistry students should understand the difference between electrolytic and voltaic cells, as they get involved in activities that involve movement of ions. In organic chemistry teachers ought to use organic materials that students come across in their environment in order to draw the attention of students. However, there was need to have further research to find out whether the students taught by the SMASSE in-serviced teachers had an advantage over their counterparts taught by those who do not attend SMASSE organized in-service teacher education programs. This study only focused on teachers' lesson planning and implementation following their in-service courses as in-service teacher educators, heads of department and practicing teachers. There was also need to find out whether the SMASSE in-serviced teachers planned and implemented their chemistry lessons differently from those who did not attend the in-service teacher education programs.

CHAPTER 6

MULTI-SITE CASE FINDINGS FROM CHUI DISTRICT

In this chapter, individual and focus group case findings from the participants (Sita, Saba, Nane and Tisa), who were teaching in different school settings (boys' boarding, Girls' boarding, mixed boarding, and mixed day) in Chui District, are presented. The participants' class sizes ranged from 40 to 50 students, depending on the school category. The District schools had a large number of students in class. The secondary school science teachers in Chui District taught across the grades (9, 10, 11, and 12) using a national spiral model curriculum. First, the individual case findings for Sita, Saba, Nane and Tisa, based on individual interviews, class observations and teacher reflections, are presented. The individual participant cases are followed by findings from a focus group interview in which Sita, Saba, and Nane participated. A summary of the findings has been considered at the end of this section. The following are the findings from Chui District for all the four participants, starting with Sita.

Sita

Teaching background. Sita started teaching in 1978 as unqualified teacher after his ordinary level education at Managu high school. His teaching subjects at that time were chemistry, biological science with physics, and mathematics. He also taught for one year after his advanced level education.

He started his university education in 1981, where he majored in chemistry. His first posting as a graduate teacher was to a girls' school where he taught chemistry and mathematics. He had been teaching the two subjects since then. Sita had taught as a professional teacher for twenty years. Sita was happy to note that some of his former students had qualified as chemistry teachers and were teaching with him at his school.

According to Sita, his "love for chemistry started in 1974 when he entered Form One" because he had a very interesting chemistry teacher. They used to do most of their chemistry work in the school laboratory and attended the science congress meetings. As Sita put it "I used to see a lot of interesting things during our congress. And that made me to like the sciences especially chemistry and therefore when I liked it I developed a liking for it." Sita felt that he was an excellent student in the science subjects at ordinary and advanced secondary education levels.

Sita's education to become a chemistry teacher started with his exemplary performance in mathematics, physics and chemistry in high school. At the university he majored in chemistry, in addition to the education courses he did to become a professional teacher. As chemistry major, Sita did more units in chemistry. Sita said:

> …majored in chemistry means you slightly do more units. There are more units you do. You do things like industrial chemistry, environmental chemistry, analytical chemistry, organic I up to organic IV chemistry, physical chemistry, electrochemistry. You slightly do more units, let me say. In fact there are a lot in the bulk of it, almost complete chemistry course. That is what we mean by a major. A minor almost does almost a half of what you do because you have to do a second teaching subject.

In the education courses, they covered teaching methodologies, made teaching observations, and excursions to industrial sites. He also did student teaching practice before he graduated as a chemistry teacher. On what he did at college to become a chemistry teacher, Sita said:

> Again teaching methods we do in terms of education, teaching practice is there, you go out for trips to see industrial [sites] for industrial chemistry to see what is happening. We do also observations before we go out into the field to do even teaching practice. So we observe as teachers, we go and see how other teachers are doing.

On his preparation to become a chemistry teacher, Sita added:

> As a chemistry teacher, there are so many things, which actually you require. First of all you must have a lab. Where you go, wherever you are carrying out that teaching of yours, you must make sure you are at least somewhere where you can carry out maybe experiments. Also, you must have basic knowledge about chemistry. And especially if you did very well in "A" level chemistry-the one advanced level, and you did the first, second year chemistry in the university very well, I think you are well equipped to handle the Form one, Form four, even to "A" level chemistry. There will be no problem because most of those topics that are covered in our examinations, in our curriculum and especially the topics in the chemistry are within a range, although we slightly again do more.

Sita felt that he had been well prepared, at the university, to become a chemistry teacher.

Sita's appointments. Sita was appointed the principal of the school he was teaching in since 1991 after working for about seven years teaching as a qualified teacher. He had been a school principal for about thirteen years. On his responsibility as a school principal and still a practicing chemistry teacher, Sita said:

> I am the principal of this school. And I am very proud that because of my chemistry it made me to be considered on this because I used to excel very well at my former school, where I was teaching from my first year, after my university course...So that is what gave me that promotion. And then as a principal as per now you can see my two lab coats here. I handle the subjects. In fact it is now that you are seeing them there. I am ever in these lab coats wearing them. That is why I have ended up actually building up two laboratories in the school. Reflecting back to my former school I used to do physical sciences.

Sita was able to cope up with his school responsibilities and teaching assignments because he continued to attend seminars on science education. As he put it:

> And at the same time there is in-service which we go after the course (pre-service teacher education). We are in-serviced to up date ourselves. We attend seminars, like the national seminar, teaching of science in secondary schools, which was actually organized by the University of Nairobi. So we attended that and that one actually motivates us and puts us on higher alert on modern changes in the teaching of chemistry.

Sita, having been a teacher for many years, seemed aware of the role of in-service seminars in enhancing chemistry teaching and learning. He had had a chance to attend some in-service seminars prior to the SMASSE in-service education programs.

Sita's chemistry teaching prior to the SMASSE project. Prior to the SMASSE in-service project, Sita mostly used to cover the chemistry unit content theoretically and occasionally would have practical sessions. On his teaching of chemistry before the SMASSE project, Sita said:

> …mostly I used to base it on theoretical, theory in class, we handle it for quite some lessons. Then we arrange for a practical session, specifically a practical lesson, especially in "A" level and even "O" level in the previous (referring to the previous 7-4-2-3 education system). So, the practical used to have its own sessions actually, and the theory its own sessions. So we would use the theory in class, use a lecture method.

During the practical sessions in the laboratory, Sita involved his students in performing experiments that were based on the manuals he used to prepare. As Sita commented:

> From the students' probe, where you probe from the students and then you arrange on the same topic, you arrange to go to the lab. That is the time the students come to the lab, you give them manuals. And then they actually carry out that practical for that particular session.

Sita's prepared laboratory manuals were in three parts: quantitative, qualitative, and volumetric analyses. The students used to do the experiments independently but following the teacher's prepared worksheets. The practical sessions were followed by theory sessions. Sita said:

> Before the SMASSE project, I had a manual, which I had actually prepared on practical, on experiments on various topics. On the first part was the quantitative analysis, second one is qualitative and then last one on volumetric analysis. Anyway, in quantitative analysis that manual is the one, which I was using. I was giving to the students [and] we used to carry the experiments independently. Then the theory lesson, the theory, independently.

Sita used to make changes in his subsequent lessons if he found his students were not following the experimental procedures as he expected them to do. He set questions that the students had to answer through laboratory activities. Sita used the prepared manuals as lesson plans for various topics on practical work. As Sita put it:

> And now when we are assessing them we could carry, you give them again the practical, you set the questions, you give them, they do it in the lab and the theory separately, when it comes down to assessment. However, the assessment is not very far from what we are doing. But the method of handling the lesson plans was that I had prepared a manual myself, of course a manual with a number of topics, from various topics, with the various experiments, on the procedures, apparatus required, and what the kind that works. So those students worked on those things, that is, before SMASSE.

From Sita's discussions, he taught chemistry units as practical and theory sessions. There were times for a theory lesson and times for a practical session in the laboratory. During the practical sessions, he used the prepared experimental manuals as his lesson plans. He had opportunities to assess his students' level of achievement in class to plan for subsequent lessons. He used to assist his students understand chemical concepts through further questions and laboratory activities.

Participation in the SMASSE project in-service program. Sita came to participate in the SMASSE in-service programs because his Gucha District was one of the districts that were selected to pilot the project. He was a very active chemistry teacher in the district. He participated in many activities to promote the teaching and learning of chemistry. He was an assessor of student work during the annual district and provincial students' science congress meetings. He was selected to become a district in-service educator through an interview conducted by the district education officials in Chui. Sita said:

> …our district, Chui, that is the time our district was starting this (SMASSE) program. And I was a major chemistry teacher. I have been participating as an assessor in the chemistry in the science congress and up to provincial level. And my students have been doing well and actually I was identified through that. And through my performance, I was identified as one of the participants in chemistry. So when they advertised, actually the moment they advertised for the posts, I developed an interest and I was interviewed and then…I was considered and I joined it with all the pleasure.

As a students' science congress assessor, Sita added:

> During the science congress, we have students participating in various subjects: chemistry, physics, biology and mathematics, and sometimes agriculture. But in my area of chemistry I am the one who does the judging, grading of the students. Then you get the positions for the various projects, which they exhibit, and talks students actually make or prepare.

Sita participated at various levels to promote the teaching and learning of chemistry. In addition to being an assessor, he was the chairman of the students' science congress in Gucha District. He had also been the treasurer for the science congress in the district. Prior to the original Simba District being divided into two districts (Nyati and Simba) and later the Simba divided into two (Simba and Chui) districts, Sita was an organizing secretary of the students' science congress in the original district and later in the Nyati District. As he put it:

> I have participated as an assessor at the district level and have become the chairman of the science congress. In the larger Nyati, I was the organizing secretary, the larger Simba when we were one Simba, then one district. And then I came here I then became chairman, I became a treasurer and I have been assessing from the district level up to provincial level.

Sita seemed to be a very active classroom teacher and appreciated working on many activities that promoted education in his district. He had great interest to participate in the in-service education programs as an educator.

The major benefits received from the SMASSE in-service program. Sita felt that he had benefited from the SMASSE project in terms of the interactions he had with his colleagues. During the interactions, he learned about his colleagues' way of handling the teaching of chemistry in their schools in relation to his teaching approaches. Another aspect that Sita gained from the in-service courses was the new approach of lesson planning and implementation. Sita argued that there used to be nothing wrong to his way of teaching chemistry prior to his attending the in-service programs, but the ASEI movement and PDSI approach to chemistry teaching and learning were extra skills he needed. As Sita put it:

> The new approach, which I have found, somehow matching with the modern method of teaching, is the participation of the students. As you are going on is very important because once you are carrying out the lesson and students participating, I think it gets on very well rather than just preparing, giving the theory and later on you come to give with the experiments. I think that is the most interesting part, which I actually found is very interesting and is good.

One thing that Sita learned that he did not know already was how to use locally available materials to improvise various apparatus to conduct experiments in chemistry. He was exposed to improvisation activities at the SMASSE in-service courses. Sita said:

> In SMASSE, there is a lot of improvisation, a lot of improvisation. That is one thing I learned and because we used not to sometimes in our schools, some of these are [district] schools, they don't have enough facilities. But as we attended the SMASSE, I found a lot of things you can use due to as we were going on in the in-service. Improvisation is a very major factor there and student participation. Student participation in the activities, in other words in terms of activities as you [inaudible] you are teaching the subject. Those are the major things I have learned and I feel are very unique in the approach in the teaching of the chemistry after the SMASSE in-service program.

On the chemistry learning activities that improvised materials were used, Sita said:

> …we have experiments where you need all the students actually to carry out and you can not afford to buy beakers which are very expensive for a whole class, that is of about fifty (students). But you find there are cans which are thrown here and there which you can re-use and wash and re-use. Food cans which are a waste which you could collect, students can be able to collect from homes. In other words this re-used, recycled for this things are already a waste but which can be re-used are the ones you collect in the lab and then you use them instead of beakers.

Sita had learned how to use improvised materials to teach organic chemistry. As he put it:

> ...in terms of organic chemistry, you get starting off with organic materials. We have the polythene papers when we are talking about the alkenes, there are things we collect around, like the polythene bags for example, which we have at our disposal around, which you can comfortably. And we use the spirit lamps instead of the normal gas. So those are very interesting. We use things like alkenes, alkynes we use things like turpentine which is very available. We just buy them in the shops very cheaply. We have paraffin, the normal kerosene which we use in our hurricane lamps, we use it and you can nurture the students very well, to be familiar with alkenes, alkynes, which is very okay.

The use of improvised materials had reduced the cost of conducting teaching and learning activities in Sita's classes.

The SMASSE in-service program's influence on lesson designing. Prior to the SMASSE project, Sita's lesson planning did not consider the students' involvement very much. Sita used the SMASSE lesson plan format to prepare for his chemistry lessons. This was a big change in his lesson plan preparation unlike before where he used his lesson notes and student laboratory manuals as the lesson plans. On the influence of SMASSE on his lesson planning, Sita said:

> …before the SMASSE incidence, there was no much involvement actually in terms of student activity. However…now in this after SMASSE, the design of the chemistry unit lesson plan, we involve the student a lot. There is a lot of student involvement, student activity, which actually are student-oriented activity. That is the major thing, which features very well, in the new lesson units that we prepare after SMASSE unlike in the previous ones, where the student activity was actually minimal in some of the lessons, apart from when you are in the lab.

In Sita's traditional lesson planning "there are no steps, which guide the students to participate so much unlike in the SMASSE where the students can participate." Sita taught in a district school with limited conventional facilities to teach chemistry. However, he had developed improvisation skills that were useful in planning and implementing chemistry unit lessons. Sita was able to design lessons that were student and practical oriented. Sita said:

> And improvisation…is a very important thing in this SMASSE issue, because in the traditional one, there is no much improvisation. We were relying on those commercial things, which you buy from the shops but in this one we have everything around our community thinking.

Sita was able to make changes in his lesson planning following the SMASSE in-service education. He was able to collect the materials he required in advance, especially the locally available materials for improvisation in the chemistry unit teaching and learning sessions. The advance collection of materials and availability in the school had made Sita's lesson planning to be stress free. As Sita stated:

> What I have done in the design of the chemistry unit lesson plans is…the things we use in the improvisation. We have tried to collect them and equip them in the lab because they are the ones we will be using…in various classes, and so that we don't have to be involved in buying…So there is no a lot of spending in terms of preparing for lessons. There is no a lot of stress, even preparing the lab is faster. You can go comfortably in the lesson and there is a lot of confidence anyway in this SMASSE lesson because the materials are there unlike where you have got to arrange and buy them. So when you are preparing this you are sure the materials are there. So you fully go ahead and around the lesson without any problem.

Sita made the changes in his lesson plan designs because his was the only one teaching chemistry and sometimes he made the changes to accommodate the cooperating, especially beginning, teachers in his school. As to why he made changes in his lesson plan designs, Sita said:

> The reason is teaching…I am the only one who will be teaching chemistry because we might have other teachers who are teaching there. So when I prepare those changes, the teachers who were there also they are colleagues, they are cooperating teachers whom we teach in the same subject. So we also have got to come in and participate and therefore also some of them maybe who are new, who have come from college, and I have got to induce them or induct them to this SMASSE issue.

Another personnel that made Sita to make changes in his lesson plan designs, were the laboratory technicians. In Kenya, the science teachers are assisted by the laboratory technicians to conduct experiments and maintain the school laboratories. The technicians are educated on conventional equipment. A teacher who wanted to improvise items for his class experiments had to induct his laboratory technician on what was required. The SMASSE in-service education program did not cater for this cadre of personnel in schools and yet they are very important in the science laboratories. On how the laboratory technicians influenced Sita's lesson planning, he said:

> Similarly we have also the lab technicians who have not undergone SMASSE [education], I am also there. I am the one somehow to also bring them up to, up date them on these related developments in terms of [improvisation], how to preserve these materials. And that is why actually I have, that is what has made me, in terms of cost, it comes fairly comfortable. And at the same time also we have in this school when we

> have no money in the school. Of course we have these things there, volley ball there (referring to his school needs and the financial situation, and therefore use of improvised materials), even the overall the whole process is very comfortable, we do not strain" so much. That is what actually we have decided to make all those changes so that we can be comfortable in teaching.

On the level of education for his school laboratory technician, Sita said:

> Like me I have one lab technician who has "trained" from the institute of science and technology and is employed by the Board of Governors. This man has gone there and has "trained" well. He has "trained" in the old because there is no SMASSE, we have not moved being a new area, SMASSE, is a new project. It has not infiltrated up to the institute of technology "training", those people and they are fairly not so high like the way in terms of education like the way we are as teachers…He needs, when it comes to school now, to handle and to take off the laboratory, apparatus, assist the teacher in preparing the lesson if it is a practical, assemble those materials, and keeping those materials safe. So you see this man needs to be updated so they can keep the lab, laboratory storage, what and in a safe situation.

The laboratory technicians in Kenya are educated in middle level colleges such as the polytechnics and institutes of science and technology. They either take certificate or diploma courses. The technicians manage the school laboratories under the guidance of the science teachers.

Implementing chemistry unit lessons following the SMASSE in-service program. Sita implemented SMASSE-oriented chemistry unit lessons in his chemistry classes. As he put it:

> ...after SMASSE, we introduced now…the students were now involved, the activity, they were involved actually. So as we go on in the topic you could give them maybe a little session because they also participate...So in other words the theory looks as if you are carrying out a practical. There is an activity going on. There is no specific time that this time now is for the practical and this time is for the theory. That is the difference. That is how we handled; there is more of student participation especially now even when you are going on unlike in the previous when we used to carry it separately.

Sita had more student-centered activities and used the plan-do-see-improve (PDSI) approach in teaching chemistry in his classes.

Conducting lessons on the Periodic Table. When teaching the periodic table unit, Sita had his students draw big charts on the periodic table that were hang in the laboratory conveniently for all students to see. Sita perceived that the periodic table charts reminded his students about the patterns in properties of elements they covered in class. Sita said:

> I took you to my lab, I think you noticed that I have gone ahead, they have drawn a very big periodic table which they have displayed to the students and it makes it comfortable. In other words there is that seeing, seeing issue. The students' seeing that periodic table, in itself, is very comfortable.

Sita ensured that he thoroughly covered the atomic structure and the pattern of properties in reference to the periodic table. All students in Sita's school took chemistry. He added:

> And coming to the periodic table, you have put it there, you have set it there. You have done the periodic structure, you have drawn an atom what it is, you have put it for the students be able to see there, you are asking some exam question, they are trying what is in that group, how does it look like? They sort of get very close than when you tell them theoretically in the old method, which we used to use actually it was very difficult, students could find it somehow hard but the subject, you find most of the students were not even taking those subjects. But it says every student like in my school now chemistry is compulsory. Chemistry is compulsory. Yeah they do it up to Form four.

On how he conducted inquiry-based teaching in his chemistry lessons, Sita said:

> There are sometimes you ask them why are these elements in the center? Why don't they have their group? Is their group not indicated here? Such kinds of things, students will tell you this. What do you think is the main reason? How about these group VIII elements, why are they there? How many electrons do they have? Such kind of things, I think you learn to know when they are getting that, giving the right answer. Then it means they are getting it. If they are not getting then it means you must get down and get to what we call electronic configuration, electronic structure. So that they know from there and then you now go to the periodic table. You can't go there without reminding about those concepts.

From Sita's comments it appeared as if his inquiry-based chemistry sessions on the periodic table were discussion-oriented in which students answered the teacher's critical questions. There were no library-based inquiries or student-based investigations on the periodic table concepts.

Conducting lessons on electrochemistry. In electrochemistry Sita used improvised plastic bottles, which were reusable, to teach electrolysis concepts. He used the carbon rods from dry batteries as electrodes during the electrolysis process. Sita's use of improvised materials to teach electrolysis had assisted his students to follow the abstract concepts in electrochemistry. As Sita said “the SMASSE has made sure that, because this idea of simple cells we have in a lot of things and therefore the students are able to get this topic very well.”

Sita applied the PDSI approach in teaching the electrochemistry concepts. He believed that students required certain prior knowledge before they were able to study electrochemistry. For example if the students were to be able to comprehend the electrolysis processes, they ought to have prior knowledge on electrons. As Sita put it:

> ...yeah, PDSI approach you get to the lab before let's say...when you are teaching a topic like electrochemistry, there are a lot of things you need to start with. The students must know what an electron is. You yourself you must sit down and know where are these students, where have they reached in terms of the concepts in terms electrolysis and what have you because this going to involve electrons and ions.

Implementing lessons in electrochemistry needed thorough preparations and prior evaluations of the practical sessions to ensure smooth teaching and learning environments. Sita said:

> So you must sit down and plan what you are going to do, first of all make a good plan so that these students you know they are like the other. Then you pre-test yourself. Yeah you must pre-test. So you see if you are going to carry an electrolysis experiment. You must know you are going to use carbon rods you are going to use, which metals as your rod terminals, and what is going to trouble.

Prior lesson plan evaluations were one way that Sita ensured that the experiments worked and the safety precautions taken before the students participated in the practical sessions. Sita assessed his lessons’ progress as he made changes to accommodate students’ difficulties in conducting the experiments. As Sita commented:

> so that and now make the students to come and do it, set the experiments, pass round, let them do it themselves, then as they see what is happening there, you are also supervising. And then where is the problem, then they can suggest some other things. There are other things, which might not work in some cases. You might not have for example potassium iodate and that is what you want. But you then you must also use a different compound which could have similar thing. We may not have copper nitrate but I have potassium

> nitrate what I want maybe I want nitrate ions. These are specific things so you must look for something to improvise, which will work at that particular moment. You make sure the students have to see what your target is. You must have that concept. You must pass the message to them. It will be very clear so that they are very comfortable.

During the practical sessions, Sita played the role of a supervisor. He went round in class supervising the individual students or groups as they performed the experiments on electrochemistry. On his role as a supervisor during class experiments, Sita said:

> I think this is a very important aspect especially practical because when the students are doing those, not that they know, they are not actually experts. They are setting out, you are trying to see the skills you are trying to [pump in] some skills of setting up the apparatus, the experiments, the whole thing starting to work, if it is an experiment designing or some kind of practical. In their case where they might not work, you see there could be a small error but why does it not work? You will have a reason. You might tell them, why do you think you have done that? It is very easy to [inaudible] for you. They could have an explanation. And leave alone that there is also confidence in the students.

Sita believed that his supervisory role during practical sessions in the laboratory made his students to have confidence in conducting the class experiments. The students were comfortable having an expert around them who could assist them in case of any difficulty. As he put it:

> Because any learning anywhere wherever you are, when you have somebody who knows and say in a position you are going well, I think that creates a lot of confidence. And they go ahead and do it in those books of theirs. So that is the purpose of going down and see where their problem is.

Practical sessions were followed by class discussions on the experiments done. The discussions were centered on the nature of science. Through the discussions, suggestions were generated to explain the observations made in the experiments. Sita said "and then you can get now down when you are in a group during discussion, you can point out those activities you sort out and then you suggest what the reasons were and then you will be very clear about that whatever you were doing." Sita's approach in conducting electrochemistry sessions focused on hands-on and minds-on activities following the SMASSE's PDSI approach.

Conducting lessons on the "mole concept". On the implementation of the "mole concept" lessons, Sita said that the "mole concept" was not only perceived as being very difficult to many students but it was also a topic that many students feared to learn. Sita used the dilution concept to illustrate to the students, that ions, as particles they learned, were countable. He used potassium permanganate to demonstrate that the color faded with dilution because the ion particles were being spread in solution. Sita said:

> …"mole concept" is very difficult to most students especially when I used to teach before the SMASSE. Actually, "mole concept" is very technical. The students fear it. But you approach it [using] the dilution method, diluting the potassium permanganate. Dilution method, the student has to see diluting that, I have the color fading actually, and I finally find there is no color. That one brings the students very close to you.

Sita added that the "mole concept" required technical teaching. He felt that the "mole concept" was technical to teach because it involved many calculations. Many students in turn have a poor mathematical background thus making them to fear learning the "mole concept". In Sita's words:

> …it involves some calculation. You know most of the students tend to fear mathematics as a subject in itself. And there are calculations in the "mole concept". Converting "moles" to grams, grams to "moles", molecules, a "mole" of molecules, a "mole" of ions, a mole of electrons, and a "mole" of atoms. Such kind of things we are doing, become very confusing to students.

One way that Sita believed would assist students follow the "mole concept" lessons with ease was by breaking down the concepts into manageable concepts to be learned by the level of students one had. Sita argued:

> And unless you come down in breaking down telling them what ions are, what electrons are, what molecules are. Because that is the only way they can bring those concepts down. And the only way is to get to the lab, show them a crystal for example to [condense] such smaller particles, which you can show very briefly and more by dissolving, then could see those particles.

The SMASSE in-service education programs influenced Sita's teaching of the "mole concept" lessons. His lesson presentation depended on his students' needs. Sita said:

> For example the "mole concept", right away now I am supposed to teach Form three the "mole concept", which is likely to be the first topic in Form three. But reaching them, what I saw when I reached in class, the students would not be able to recall about the particulate nature of matter. So I had to go down to see where the problem was. I found the problem was they don't know what? They have not touched on effect of electric current on substances, which is actually a Form two work.

Changes that Sita made in his subsequent lessons were based on his students' feedback. He made the changes to improve on his teaching and presentation of learning activities in chemistry. On how he went about addressing his students' problems in the areas he taught, Sita said:

> So I have got, I have designed an experiment. They have gone back now to the lab again to go back and look at that, the effect of…before I go and tell that matter, like the idea of ions, I can't be giving them, the idea of the "mole", the smallest particle, the atom, I can't bring them in because they have not got about that. When I bring ions, it means I must talk about an electron. I must have done what is the electric, how does it come in, so that is why like the "mole concept", I must go down again to Form two work to start them before I bring up the idea. And this is all, I think is…and they must do it. Yeah, because that which is actually a fair approach. So that they can relate it and that makes my work very easy in those topic areas.

One way that Sita assisted his students with difficulties in following concepts in a given chemistry unit was to refer to prior knowledge that they lacked. He had also to break the concepts into manageable units and then build on them to benefit the students.

On the other hand, Sita used models to teach his chemical concepts. Some of the models found in Sita's laboratory were improvised using locally available materials. Sita usually used the models to teach organic chemistry lessons. He said:

> We have made a lot of models, as you saw down there (referring to the lab), which actually exhibit the organic chemistry. In terms of organic chemistry we have made the models, you saw down there. We have the "Plastocene", which we use.

The use of locally available materials had made the teaching of chemistry units such as organic chemistry easy to teach and understandable to the students.

Lesson evaluations during instruction. According to Sita, “evaluation starts straight away as soon as you give the first instructions” in class. In practical sessions, the students are involved in various activities right from the start of the lesson. Sita assessed his lesson plan implementations right from the time he stepped into a classroom to teach. For the practical sessions, Sita said:

> ...they (students) are getting set up for this, you have put as per the procedure, the worksheet. Are getting seated, in the group are they setting out the apparatus in the correct way? Now, if you find that they are getting on, it means they are getting on with the worksheet we have organized very well. Then as they are going on, are they writing down the observations very well? how are they putting those observations? Is there a big variation? If you find within the same group they are writing different things, then there is something wrong with your lesson. Then there is something either some information, which has not been clear. So that is one way in which you can get feedback because you find different results happening at different levels.

In many situations the students did activities according to Sita’s expectations. He knew that his students were getting on well with their practical work when they were all obtaining the teacher’s expected results in the experiment or asking pertinent questions on the experiments. Sita added:

> But when you find results are as you expected, maybe as you have prepared, you find they are doing well, they are writing down the results very well, they are able to ask questions, there is something going on. At least they are getting what is going on.

However, Sita was able to know that his students were having difficulties in the class experiments when they were unable to answer the questions he posed to them in class. As Sita put it:

> When you ask a question and they are not [ready to answer], you might go to a group, ask them a question, where have you reached? You find they have not even started, it means there is something wrong somewhere. You must go down and see where the problem is in the process and see how it should start. So next time if you had a double class you must

> correct that kind of situation. So they have got to carry out that exercise or that experiment, that practical very effectively.

Following his student evaluations during chemistry classes, Sita attended to their difficulties either immediately in class or in subsequent lessons.

Changes Sita made in implementing subsequent chemistry unit lessons. Sita did not make many changes in his lesson plans implementations. The few changes made were different because of the different topics and classes he taught. He said:

> I have not made so many changes but changes which come up with time and mostly is concerning the, they differ from topic to topic and from class to class because you find I am handling this class and I am handling another one. So if I am handling a different class, at least whatever I am handling here must actually go down to assist this teacher (referring to his cooperating teacher) here to carry on with what I carried in that topic.

Sometimes the changes Sita made in his subsequent lessons were based on the discussions he held with his cooperating teacher. On how they exchanged ideas, Sita said:

> And we have this cooperating teacher, I mean teachers we change, we kind of exchange ideas within the department like chemistry department. So when we are having these topics, when we are handling them as a teacher, there is no much deviation, we are handling them in the way they are required with the students' participation.

Sita shared his ideas on how to implement student-centered chemistry unit lessons with his cooperating teacher because they taught chemistry in parallel classes. Their teaching arrangement ensured uniformity in what the students learned in various chemistry topics. Teachers taught lessons for their colleagues who might be absent from school for one reason or another. For the cooperating teachers and their involvement in student-centered activity lessons, Sita said:

> These are teachers we teach in the same subjects in chemistry department. Like in mine now we are two teachers. So when I am not there actually, maybe I tell him to be in charge when students are doing maybe a practical, or to handle for me a given topic. But however, I must tell him where I have reached and which materials. Because when I find, maybe, it is not enough I have got to also assist him to come up [with something] so that

> they can handle it in the way it is required and the uses of the materials so that the students in the process of learning, they have some activity at least to do.

Sita made changes in his lesson teaching whenever he found his students not remembering the work they covered in previous topics or classes. As to why Sita made the changes, he said:

> I make them to make the work....kind of flow because there is a lot of discontinuity there. When they have not got these topics, Form two topic, and I am going all of a sudden to Form three, sincerely I am being unfair to them because in between there is a gap. So to make it for continuity to flow so that the [inaudible] ions and electrodes and all of a sudden you are going up to “mole concept”. When you talk about mole of electrons they will understand it very well what I mean. “Mole” of ions they understand what I mean.

Sita implemented the changes he made in his lesson presentations depending on the kind of problem it addressed. There were changes he implemented during the class session or in subsequent class lessons. The changes were also made either at the start of the lesson or as the lesson progressed or at the end of the lesson. For example, Sita made some changes during his “mole concept” lessons in which he had to employ different strategies to address his students’ problems on what he had planned to teach. As Sita put it:

> ...the changes I make especially when I have started a lesson, I find these students have not got what I am trying to pass to them maybe that new topic, I have got to go straight…maybe call in for some chemicals, carry out some examples, some demonstration there. Show the beginning, divide them into groups and give them something, they observe and they do themselves, they try to count. A topic like the “mole concept” I have to straight away connect the cells. Demonstrate to them, show the difference between when it is in solid form and when is in ion form, I mean when it is solution form whether it conducts, and in that way then I can straight away ask some questions orally to see whether they have [what] they are seeing. Then from there I will go on with the teaching of the “mole concept”.

There were some situations where Sita had to disregard his prepared lesson plans as he made changes in class. He did that when he was teaching the “mole concept” as his first topic in a Form Three class. As his first topic in the Form Three classes, he expected his students to have some idea about the particulate nature of matter. However, in class he found that the students had forgotten some of the concepts learned in previous classes. Sita said:

> I am supposed to start from what the students should know, so that they have some idea they should be able to tell various particles, small particles-the atom, we have the ion- and I had prepared a lesson, I thought I could start straight away and go and maybe do dilution work. I found these students don't even know what an electron is, what an ion is.

The students' lack of adequate prior knowledge required in following the "mole concept" lesson, influenced Sita to redesign his lesson plan implementation. As Sita put it:

> I had to go back now to design again another Form two work to start with, which [was on] effect of an electric current [on substances]. So I was forced to change and design again another lesson plan to suit the Form two level, so that they can get that topic very well about ions, the idea of ions, what is an ion? Because they know they have a negative and positive [charge]. They only know about electrons, so when you tell them an ion they think they are the same as an electron. So when you go to Form two work, you bring them up now when you have to approach that these are ions, these are ions, [An ionic salt] when dissolved in water you form ions and so what happens you can count them.

From the discussions, it was evident that Sita was a very good chemistry teacher and had incorporated the SMASSE's ASEI movement and PDSI approach to implement his chemistry lessons in his school. He was also able to share his ideas with his cooperating teachers to enhance the teaching and learning of chemistry units in his school.

The SMASSE Project: Issues for the planners' considerations. According to Sita, the first thing the SMASSE planners were supposed to know was that the project on in-service teacher education involving four subjects was very important. He thought that it was important for the planners to first of all establish whether all teachers in Chui District had been in-serviced. He argued that "all the teachers involved in the teaching of chemistry subject must be in-serviced." He argued that there were teachers in some schools who had not been in-serviced at all. He felt that there was need for the SMASSE planners to find out how effective the in-service education was in schools within the district. Sita argued, further, that there were few in-serviced chemistry teachers in his Zone. The Zone required more in-serviced teachers if student achievement in the sciences was to be enhanced through in-service teacher education programs. Sita said:

> We are very few. We need many. So I am alone, for example, in this zone and actually there are about five schools which don't have that “trained” teacher. Me, I can in-service my chemistry colleague, what about the others? That is the first thing they should do.

Efficient and sustainable monitoring and evaluation of the district in-service chemistry teacher education was lacking. Sita argued that the planners ought to keep in touch with the teachers in the field to be able to address any problem they faced in promoting the teaching and learning of chemistry. The district in-service educators appeared to encounter myriad constraints in implementing the programs at the district level.

> ...they should also be able to evaluate through either the national examinations when these group of students reach there, what is the problem? Be able to come and reach us in the field here and we tell them exactly what is taking place. They should be able to know which schools have benefited and which schools have not benefited. And I am grateful that they have been assisting some of the schools, which are not able with chemicals, but still [need] more. There is this improvisation which is very important. Some schools they believe in these capacities, they have not been included in this...well they have tried, they have brought them to district level that is fine. But I think there is more that they should do, to visit us more to know actually our problems....

It was Sita’s view that the SMASSE project should target all schools in the district when monitoring and evaluating the impact of the in-service education programs. It would be important if the monitoring and evaluations were done uniformly at ago for the whole district.

The experience of many of the national in-service education center educators was wanting. Sita expected those who in-serviced them at the national level to be teachers with considerable amount of experience and higher qualifications compared to those who were being in-serviced. There was need for the SMASSE project planners to seriously consider the level of expertise of their national in-service educators, especially those who conducted the national in-service sessions. As Sita put it:

> Another [thing] I would like to add is experience of the national “trainers”. I had finished university in 1984. I have taught for about 20 years. Somebody has taught for about eight years, is now “training” and is having the first degree. I think it is being unfair to me

> because I don't think there is some seriousness in this issue. At least, I expect this person maybe to have masters and even Ph.D. And I will be very comfortable.

The planners ought to have considered the district in-service educators' motivation. Promises made during the in-service programs by the SMASSE national team ought to have been kept. Sita felt that their "personal happiness" factors were not taken care of. It was good to improve on the teaching skills but teachers needed to be motivated through some kind of recognition by the authorities. Sita said:

> And also the district "trainers"' motivation, we are not motivated to the way we are handled. Initially we were told we were going to be given a job group. That was the agreement, the memorandum of understanding, we were actually attending when the stakeholders meeting at KSTC. We were going to be given a job group higher. This has not been done and we have noticed that.

The planners had done very well to ensure that the project was implemented successfully in the pilot districts. However, the district in-service educators did not have much to show that they participated and greatly contributed towards the success of the implementation of the SMASSE project at the district level. As Sita added:

> Come to the certificates themselves. We were leaving after the whole "training" we were going to be full district "trainers" because we were to be given certificates to be district "trainers". We have not been given those certificates. Reasons are not very clear. I don't know, such kind of things, they affect the morale. The four-year "training" that we take in our course actually is a lot. Somebody goes for masters and that is for two years and finishes and he gets a certificate. We take four years "training", why not get even a certificate, even for masters; you know these are four years, it is almost like doing Ph.D. So I think this is something, which should be looked into, if they had done us this, otherwise it would have worked us very well.

The district in-service educators educated teachers at the district in-service education resource center. With the in-service participants, they resided in the students' school dormitories and the center provided meals for the ten days when the in-service was in session. According to Sita, the meals provided were sometimes inadequate for the participants. As Sita put it:

> And some times, when we are "training" in our centers in our district level, some times we are hungry like children and we are grown ups. I am a head of a secondary [school], I have gone to administration where there is another head and then I am handled as if I didn't even go to Form one and I am a district "trainer". I am "training" other teachers. So such kind of issues should be looked at by the administration.

Sita wanted the in-service education participants at the district level to be treated with respect. He feared that maybe the resource center was not getting the in-service logistics well. The planners ought to have known how many teachers they expected and a plan of action both during the in-service sessions and rest times. The participants were not provided with any form of entertainment in the evenings or weekends. Sita added:

> …you find sometimes either the principals are not given enough registrations or they are not given money or they feel that with these ones these are in the institution, they are not to worry, they know where they sleep. The kind of meals they take, these are "wazees" (old people) who have opted to sleep there. Entertainment, they need to be comfortable. So they are limited to sort of like students I think.

There was need to have transport available for those teachers whose homes were nearby to be picked and dropped during the in-service sessions in the districts. Provision of transport in the in-service resource centers would decongest the residential facilities and likely to motivate more teachers to attend the in-service education programs. Sita said:

> A case like in our district, Chui, if we would have the bus in the center organized in such a way that they are transported. Those who can afford to go to their homes, are transported and they are collected every morning and every evening, and they are given a good meal. If they are using their own means, their fare is refunded accordingly without any problem. And the treatment okay but in terms of meals, it is in meals where the problem is I think and where those ones who board in school, accommodation has to be comfortable.

Sita argued that the administration of the SMASSE project needed change to ensure that all participants were motivated to enhance student achievements through in-service education. Recognition of the in-service educators ought to be on merit and one's contributions in enhancing science education in his school or district. Sita commented:

> The administration actually should change completely so that we have gone to fair play. We are sincere to one another. That is the only way you can work. We first of all, the district "trainers" are recognized. If there is promotion it is done fairly. If I have been told …, I joined in 1999, when during the reception of the SMASSE, some people have "trained for two years and they have been taken to Japan. Now what does that …what are we doing we are not serious. So I think the planners must look into that so that if they got to make it so that in future the whole thing is okay….

The district in-service educators were still having their full school load. They sacrificed themselves to attend the national SMASSE in-service courses, and in planning, preparing and conducting the district in-service courses. Against this background, Sita felt that the SMASSE project planners and administrators were overlooking the district in-service educators. Other than enhanced teaching and improvisation skills in chemistry, Sita had nothing to show his seniority in the project. He was dissatisfied that his contributions were not recognized by the SMASSE planners. After the five years of the project duration, Sita expected to gain materially. As he put it:

> …especially this idea of job group should be looked at very seriously. So that these teachers are recognized very well from the district level…because they are "trainers" they should be given some recognition also from their schools. Then the number of lessons, the way they are handled, you know these are "big" people, they are "trainers", they are officers. The lessons should be reduced in their schools. They should be considered for that….

There was need for the SMASSE planners to ensure that a district in-service educator had fewer lessons to teach in school. Sita appeared to be overstretched with the teaching workload, headship responsibilities and the in-service activities. He said:

> Well like now I am the head teacher of the institution, I am a district "trainer", I am teaching, I have, we are only two chemistry teachers here, and we are only two math teachers, I am also a math teacher. So I am teaching some lessons in chemistry and some lessons in mathematics. I am handling as much as 17 lessons. Seventeen lessons in a week for a head of an institution, I am supposed to go for a meeting, you are supposed to organize and do administration in the school. It is a lot of work, let's be realistic. If there was a fair play in this, if we had maybe the number of teachers in session, so that these people are treated as HODs or what have you. I will be very comfortable maybe have

> four, five, six lessons. Even people teaching in teachers colleges, who take as little as this.

One way the in-service educators' workload would have been reduced was through posting of new teachers to their schools. The new teachers were to take some of the lessons that were allocated to the teachers who administered the district in-service education programs. As Sita said:

> One of the methods is when it comes to consideration in terms of posting of the teachers. If I can get a chemistry teacher, for example, to assist me, a chemistry /math teacher can definitely reduce my number of lessons, that is, in math and in chemistry. I can be very comfortable; maybe if I can have like eight, I will be a bit comfortable. Now me as a head there is a lot of work still. But as a SMASSE district "trainer", if I remain with eight lessons for example and I am given transport in our center, I will be able to attend these sessions without students missing the lessons…without students missing my lessons, teaching lessons, at the same time it will also enable me to plan very well for the next "training" session, in-service by preparing materials. I may even go to the national level for consultation because this is a matter of time issue but if I have seventeen lessons, maybe I happen to have only five, then, I am now becoming more of unprofessional.

The heavy workload for the district in-service educators was likely to lead to missing of some chemistry lessons in school. Many professional teachers would not like to miss their classes to attend to SMASSE activities at the district or national level. Sometimes a teacher might be unable to attend urgent SMASSE activities because no school head would release a teacher and have the students miss a lesson. Sita said:

> No head teacher will accept that you are losing lessons because you are going for SMASSE [project activities]. I mean what have you got…there is no logic in that. So I think the planners should arrange with the Teachers Service Commission to send adequate teachers to these SMASSE district "trainers" where they are teaching, they are relied off serving the lessons. And it can be effective then other things can be taken care of.

Having the district in-service educators' teaching workload reduced would give them enough time to plan, prepare, and implement the district in-service activities. It seemed the SMASSE planners had overlooked the teachers' workload in schools because they expected too much from the teachers who had volunteered to become the district in-service educators. On the importance of having reduced workload in school, Sita said:

> So these ones can also be given enough time to prepare adequate material, improvisation, new methods, have regular meetings to come up with new strategies of "training" these to be effective. So they can be able to reach these teachers if it is possible in their schools and look at what they are doing. I think that can be done and it can be very okay.

The district in-service educators needed to monitor and evaluate the impact of the district in-service teacher education through follow up activities. Transport ought to have been provided for monitoring and evaluation activities in the district. Sita added:

> And if possible, this district should be given some kind of transportation so they can reach various schools. We should be able to see what is the problem? We are unable to reach the schools. Normally we could ring those teachers, they even don't even know, some of them, maybe what SMASSE is, within the district headquarter which is a SMASSE zone. I think that one should be looked into during planning by project planners it would be very good for the teacher.

The frequent transfers of the education officials to and from the district hampered effective coordination of the in-service education activities in the district. The project ought to have ensured that the education officials directly involved in the in-service activities were left in the district during the five-year duration. About the education officials in the district, Sita said:

> And also they set permanent officers like for example in our district, our officers-the district inspectors-they have been "trained" and then they all transferred. So I think such kind of things I don't think they augur very well. These district inspectors have been "trained", they can be promoted along that one so that they continue that.

The in-service planners ought to have foreseen that without any tangible benefit to the in-serviced teachers in the five-year duration, many were to be dissatisfied with the project. Many in-serviced teachers were opting for transfers out of the district. The district was getting poor returns because they had invested heavily on the teachers. The district met the expenses of in-servicing the teachers in terms of accommodation, meals and materials used during the in-service sessions. If there was a way of recognizing the in-serviced teachers, the districts that were investing colossal amounts of money to in-service their teachers would be proud for having done so. As Sita put it:

> And also some of the district "trainers" have opted for transfers because they have not seen anything tangible. The way they are being handled, I think they are discouraged…So if the planners can look into that very seriously at district level, at national level, also the motivational aspects of it, the administration aspect of it, all will be very okay. I think because at this (district) level we pay the money, giving out the money is very okay. We should make it sort of friendly like the way we have what we call our lessons after SMASSE, we say ASEI lessons are normally…teacher friendly and even to students. So I think that is very important.

The SMASSE project focused on hands-on and minds-on activities. However, many district schools, including the school where Sita taught, in Chui had inadequate provision of science facilities. In addition to the district in-service resource centers, there was need for the SMASSE planners to strengthen secondary school science through provision of science facilities in the district schools. Improved teaching skills were very important aspects of teacher education but teachers needed appropriate facilities to implement the school science curriculum as was the case in the national and provincial schools in Kenya. Sita argued:

> Like now in my school here, Bokeira secondary school in Chui. I have a twin lab there but it is unfinished. There is no gas fittings, no water, there is no light, you have seen even in the office here we are straining to see. So some of those you see if we could get assistance in some of these things. When it comes to rural electrification, water, some assistance if we can be assisted, some of us I think we can be models around here and some of the schools will be coming to like my school here as a model school…As much as we have a building, the building is very good, a twin house with a store but there is nothing in the store, very few chemicals because of the finances and what have you. And there are many schools which require our services again to assist them.

Sita appealed to other well wishers to assist his school in the provision of the science facilities to benefit the youth in learning science. He appreciated the donations that the school had previously received from the World Bank, but as a young district school, it required more assistance. This was an issue that the SMASSE project planners would consider in their future promotions of student achievements in science. On need for assistance to be extended to district schools, Sita said:

> Our friends initially in 1981 [the] World Bank which donated some apparatus that have assisted the school a lot and that time the school was extremely young. But the parents have come together and they have actually put up the building. Now if our friends like the JICA who can assist us, our government, for example, have got that program, sometimes they assist. The Kenya government can assist to put up some electricity, things like the SMASSE project can assist in putting up some of these things like the gas. You saw how many things are missing if they can assist some of the things that we don't have like a photocopier, and many things we are missing. If we can be assisted by our government, SMASSE group, JICA and other well wishers, we will be very grateful in fact.

From Sita’s appeal for assistance to his school, it was evident that the district schools had many constraints in implementing the chemistry curriculum. The schools needed adequate provision of science facilities in addition to the in-servicing programs that the SMASSE project conducted. The SMASSE project in-service education planners had a role to play in the provision of these facilities in schools. By so doing, student achievement will be enhanced in chemistry.

Saba

Teaching background. Saba started teaching in 1990 after being educated as a science teacher majoring in mathematics and chemistry. After graduation, he was posted to Siange girls' high school, a school he was still teaching in. He mainly taught chemistry, although mathematics was the other subject.

Saba was prompted to become a science teacher because of the interest he had in science from his secondary school education. He was motivated by his chemistry teacher's teaching and mastery of content. As he put it:

> Since my "O" levels, I was very much touched by the way our chemistry teacher used to handle the subject and that was Father [McMullan], a Briton. He used to teach us very well. We enjoyed his lessons and from there I developed a very positive attitude towards the subject. And from there on, I continued liking the subject and that is how I came to "train" in this particular subject.

Saba was educated to become a chemistry teacher at The Kenya Science Teachers College. At college, he learned chemistry content and subject methods before he did his student teaching practice for three months. On his preparation to become a chemistry teacher at college, Saba said:

> Well from college, I can be able to say we were given subject methods, particularly in chemistry on how to handle the subject. After I left college, I have been using the teaching methods and developing them appropriately after college. So what I would like to say here is that I have been using the methods well. I have been giving the practical approach to teaching as I was taught in college but certain situations could arise whereby we did not have enough materials. I could say I never used to engage myself more on improvisation. That was after "training" from college.

Prior to the SMASSE in-service education, Saba engaged his students more on theory-oriented than hands-on activity-oriented lessons. The students were however engaged in class discussions during Saba's chemistry lessons. He said:

> Before the SMASSE project, I could say that my theory lessons used to be more theoretical than activity oriented. Yeah, it used to be very much theoretical. Students

> were not involved so much...the instructional methods I was using during that particular time were more like lecture, involving students in discussions, discussions without so many activities. We used to discuss well but I think student activities were not so much

Occasionally, Saba engaged his students on practical work in chemistry. The students performed class experiments if Saba felt that the experiments did not pose any danger to the students. In cases where class experiments were not possible, he conducted teacher demonstration sessions. As Saba put it:

> …on practical lessons, it could probably depend on the type of experiments to be done. And in this particular case there are certain experiments where you find it could be difficult to organize for every student, and that particular experiment I could not organize a class experiment. In that particular case I used to do teacher demonstrations. So that I could demonstrate to the students what is supposed to be done.

During the teacher demonstrations, Saba's students were engaged in assembling the apparatus. On how he conducted his practical sessions, Saba said:

> On certain occasions if the experiment is not dangerous or so something like that the students can be involved in assembling the apparatus for that particular experiment and that is how I used to involve them. But then if I have enough materials I used to give a class experiment where the students could do the work by themselves and then we discuss at the end of the experiment.

The students were involved in making and recording their experimental observations. Saba would later guide them to discuss the results of the experiments done. Discussions based on the observations made provided Saba with a feedback on his students' progress in learning the chemical concepts illustrated by the experiment. Saba noted:

> …after doing the experiments there is an area of observations which they are meant to record, we used to do that. Then our discussion was to dwell mainly for me to know whether they made the right observation and in areas they did not make observations then we could discuss it out. And if we need review we could do the experiment now together so that the right observation is noted.

During the practical sessions, especially in class experiments, Saba played a role of a supervisor. He moved around in class assisting the individual students. As Saba put it:

> …my role during that time is to move around the class to the various groups that are performing the experiment. If it is an individual's experiment, I could still move around and see whether the students are doing the right thing. And if they are doing the wrong thing I give advice on what should be done.

Saba used to prepare worksheets for the class experiments. The worksheets had questions that students had to answer after conducting an experiment. This was another way that Saba ensured that the students were involved in learning activities. Saba said:

> …if it is a practical experiment I normally had prepared worksheets and the prepared worksheet at the end of it has the questions. And students could answer those questions. Those are some of the activities I used to give them.

Students were guided on how to make their own lesson notes during Saba's chemistry class sessions. As Saba put it "in most cases, they used to write on their own and when I felt there are certain areas where I need to emphasis I used to write that on the board."

On how students made notes during his chemistry unit lessons, Saba, further, said:

> And in terms of giving notes I encourage my students as I teach they make notes. But at certain times I as a teacher I used to guide them on how to make the notes and give particular reasons this is an important point we could note this point down. So I used to guide the students in making notes.

Saba involved his students in class discussions. The class discussions on the experiments done were then followed by lesson conclusions. In the lesson conclusions, Saba highlighted the main points of the lessons. As Saba put it:

> I used to conclude my practical sessions, after the discussions, after making the right observations and corrections about what was to be observed. Then we could conclude by highlighting the key points about the lesson and making a summary of the lesson by highlighting key points.

Prior to the SMASSE in-service education, Saba felt that he had no problem at all with the chemistry content he taught at the secondary school level. On the level of his content knowledge in chemistry, Saba said:

> On content I could say after my “training” at "O"(ordinary) and high school and college I felt I had enough content to teach. And I found the "O" level content quite not too challenging, not challenging to me to say, I had content to teach actually. I had no problem with content.

Perhaps, what Saba needed was to enhance his pedagogical knowledge through in-service education programs.

Reasons for participating in the SMASSE in-service program. Saba started to participate in the SMASSE project activities because his district was one of the nine districts selected to pilot the in-service science teacher education. According to Saba “some teachers had to be selected to join the project and it so happens that I was one of the teachers who were selected to ‘train’ at the national levels from our district.” From Chui district, Saba was one of the four chemistry teachers interviewed and selected to be in-serviced and become the Chui district in-service educators for chemistry.

The major benefits received from the SMASSE in-service program. Saba observed that he had been able to improve on his teaching methods particularly on areas of improvisation and encouragement to have practical-oriented chemistry unit lessons. He had been able to add more activities to his lessons and he felt that he involved the students more than he used to do prior to the in-service education program. Following the in-service education, he always considered students needs when planning. In experiments, he always had the students in mind and as much as possible encouraged experimental approach by doing more class experiments. He gave his learners opportunities to assess the lesson. He involved the students in lesson evaluations. The students’ feedback assisted Saba to improve on how he presented the chemistry unit content during the lesson or in subsequent lessons. Saba said:

> So I am able to know in this particular lesson by my way of approaching it, this is the way I approach this; this is what was not understood well. And it helps me to plan for the next lesson.

Prior to the in-service programs, Saba was not so much involved in improvisation because of pressure of work. He argued that the workload sometimes was so high and yet there were no "guidelines on how to improvise certain materials for carrying out experiments. And I think with this area of improvisation I learned more about it through the SMASSE project." Saba gave examples of the types of improvisation he conducted in his school. On improvisation he commented:

> For instance, we don't have to prepare gas using a flask, a glass flask and or that. You can get a transparent polythene paper, you put the reagents there, it reacts very well and you collect the gas, just by connecting some tubes and you are able to collect it. That is one area of improvisation. When it comes to organic practical we have been able to use marbles and we paint them different colors and we are able to make those practical with the students and it is quite interesting to them.

Saba had been exposed to other activities that he involved his students in. During the in-service education, he learned more about activities such as concept word mapping, key word sentences, word burrs, and directed activity related to a text (DART). These activities made theory lessons more interesting and enjoyable to the students. As Saba put it:

> …even if it is a theory lesson, to make it more interesting I include the activities, through discussions, other concepts, which we learned during our "training" at the national level like DART (directed activity related to text), concept word mapping, word burrs, and all those. I think they are helping our students during our discussions.

On DART, Saba involved his students on comprehension activities based on scientific passages. The passages were related to the topic he taught. He gave DART activities to have his students improve on scientific language and communication skills. On how he conducted DART activities in class, Saba said:

> …there are certain passages like for example if you are talking about a topic, you find there is a passage, a chemistry passage, scientific oriented, information results or there. Now from there you can set something like a comprehension sort of questions. The students read the passage and then from those questions you will see are they able to interpret the concepts from the passage correctly, are they able to direct questions to what is in that particular text. And that one helps me a great deal to know how students

> perceive things, how they understand science, like the way they are going to interpret the text.

Saba had also benefited from the in-service education project in terms of lesson planning and implementation. He was able to plan in advance on how to evaluate his lessons using his students. The feedback from his lesson evaluation had made him to improve on his subsequent lessons. As he put it:

> …at the end of the lesson for instance, I could tell the students okay we have come to the end of our lesson, what is your opinion about this lesson? Which concepts were not very clear? Which concepts did you understand very well? How do you think this particular lesson can be made better if it were to be taught the second round? And that is where I get the students' opinion and at the same time able to assess how I taught that particular lesson.

On the other hand, there were some concepts that Saba learned from the SMASSE project that he did not know how to handle them prior to the in-service programs. Through the in-service courses, Saba learned on how to build his students' confidence in chemistry classes. In his own words, Saba said:

> I learned how students build their attitude. And it has helped a great deal because as a science teacher, the mind development of the students, for instance I have learned that when I am teaching I need to develop my ideas from a simple situation and then I build it up. And in that way students learn to relate ideas. So SMASSE has helped me to more or so implement this, like this kind of teaching method of using unknown to known...

On other benefits he received from SMASSE, Saba said:

> …SMASSE also gave me the opportunity even to go to Japan. And as I was there, I equally learned a lot particularly on the area of improvisation, which I am really using now in my teaching. I feel I have really benefited from SMASSE.

Saba was one of the few district in-service educators who had an opportunity to visit foreign countries to learn more about their science education programs.

Designing chemistry unit lessons following the SMASSE in-service program. Saba felt that the in-service programs had influenced his design of chemistry lessons considerably. He prepared modified lesson plans compared to those he had learned in pre-service teacher education. He designed student-centered lessons that incorporated lesson notes and evaluation plans. On whether the SMASSE project had influenced his chemistry unit lesson plan designs, Saba said:

> …it has influenced a great deal because other than the way I learned to make a lesson plan in college, now my lesson plan is modified in a way that it includes all the activities that are to be done. My lesson notes are within my lesson. So in the process of planning I have the students in mind. At every stage I know what I am supposed to do. And at every stage and during my teaching, I must have raised everything that is required during the lesson for easier execution of this particular lesson.

Saba planned and prepared his chemistry unit lessons based on SMASSE's ASEI movement and the PDSI approach to teaching. The ASEI lesson plans focused on student-centered activities whether it was a theory or practical session. Saba noted:

> So from SMASSE we have learned what is called PDSI…but I wish to say that, now in my lesson planning, what we have learned from SMASSE, the PDSI approach to teaching, that is, planning-doing-seeing-and improving. That means in the process of planning my lesson, I do it and then after doing it, I have to see did it flow the way I had planned? Why didn't (the lesson) flow? And then I improve next time. This is also in like with what we call ASEI movement. That is activity, student-centered, and experimentation and improvisation. So I am engaging students in more activities and my approach to teaching is more experimental and I am now improvising in situations where I don't have the equipment.

Saba incorporated the lesson notes in his lesson plans to make his teaching easier. Previously, it was cumbersome to carry the lesson notes and lesson plans separately to class. Saba found his new lesson plan format teacher friendly and appropriate for him to use in school.

On the other hand, Saba's changes on his lesson plan designs depended on the resources available to implement the lessons he prepared. Saba commented:

> …what influences me are the available resources…for instance, if I am performing and experiment, do we have the materials required to perform that experiment? Are the equipments available? If they are available I plan with them in mind. If they are not available then I will improvise on what to do, yes, with the students in mind.

Saba prepared lessons which had student-centered activities. As he put it:

> …to ensure that the ASEI movement is working…I have to set my activities with the students in mind. This is the experiment, how am I going to involve the students in performing this particular experiment, so that there are more student-centered than teacher-centered.

Saba's lesson plan designs catered for student activities to avoid teacher-centered lesson plan implementations.

Implementing chemistry unit lessons following the SMASSE in-service program. During Saba's in-service education at the national level, they prepared sample lesson plans on some topics of concern. One of the topics was the "mole concept", which was one of the secondary school topics that "students fear most because it involves a lot of calculations." Saba renewed his approach to the teaching the "mole concept" to "demystify what was there among the students." Saba taught the topic using students' real life experiences and situations. He used students' familiar counting units to relate to the "mole" as a unit of measurement of quantity of material equivalent to the Avogadro's number. Saba said:

> We talk of a dozen, a dozen stands for twelve items. If it is a gross, it stands for certain quantity of items. So when I am even defining the word mole, I use that idea, so that I say a mole is just like a dozen which represents a certain number of particles, the Avogadro number of particles. And I think after using that kind of message I find the students come to understand more what really a "mole" is.

Saba taught the "mole concept" using a practical approach. He involved his students in the practical sessions to assist them understand the "mole concept" better. Prior lesson arrangements and planning made Saba's teaching attainable and beneficial to his students. He used student worksheets during the practical sessions. On how Saba implemented and involved his students in the practical sessions, he said:

> …when I have, for instance, a double lesson, that is, the lesson when you normally conduct our experiments, I have to prepare as a teacher earlier enough to ensure that the materials are ready in the lab, the equipment and everything is ready before the students come in for the lesson. So once everything is ready we normally go to the class, introduce the lesson, introduce to the students what is to be done. I ask the students to get the equipment and materials required for that particular experiment. I give them worksheets, I give them instructions on what is to be done and the instructions are very simple and clear to understand. So the students work using their worksheets.

There are many experiments to be conducted when teaching and learning the "mole concept". The experimental reactions involved writing chemical equations and doing calculations. Saba said:

> …when I am teaching a topic like the "mole concept", you know here reactions, there are so many reactions taking place, there are so many equations to be written down, there are so many calculations to be done. So what I usually do is that when I am teaching this particular topic, If a particular reagent, particular reagents are reacting, then I will just tell the students this and this is reacting, the experiment's products.

The students were involved in various activities when learning about the "mole concept". Saba made them to participate in writing the chemical equations for the reactions covered in the class experiments. He also involved them in calculations based on the experimental results and led them in discussing the concepts learned from the experiments done. As Saba put it:

> I use the students to write the equation rather than me writing it. And whenever they make a mistake we correct it together. When it comes to calculations, I equally involve the students to calculate on the board as others are discussing and we correct whenever a mistake is committed. So those are some of the activities I am really engaging the students in.

As Saba argued, "the calculations were more mathematical and students had mathematical background." During the calculations, he gave examples on how the students were to solve a particular problem. He then gave students a problem to solve to "see whether they are able to work on their own." And wherever they were unable to work out the problems, Saba involved the students in class discussions as he guided them to the correct solutions. On the tasks the students were involved in, Saba said:

> So when it comes to calculations...I give them tasks, I let them work out and whenever they make mistakes or they are unable to complete the tasks well, together we share and give more tasks to them to see whether they are getting the concepts when it comes to calculations.

On the nature of the calculation tasks, Saba expected his students to be able to calculate molarity and relative molecular masses from titration experiments. Saba gave his students calculation problems based on the experiments done and also theoretical calculation problems involving the "mole concept". As Saba said:

> …an experiment…let's say a titration experiment, where they have to calculate the number of moles, they have to calculate things like molarity, they can even calculate the relative molecular mass from the experiment. So that is a practical approach to this experiment but I can give them theoretical questions related to the experiment. That is a task I give them but related to the experiment and if they are able to work them out well and good. So the tasks I give are theoretical questions related to experiments on the "mole concept".

Saba was applying the concepts and skills he learned during the national SMASSE in-service education programs to implement his electrochemistry lessons. He had learned how to demonstrate the flow of charges when teaching the electrochemistry unit. Using a solution from red cabbage, as an indicator, and improvised electrodes, he was able to demonstrate to his students the movement of ions during electrolysis. On how he implemented the electrochemistry unit, Saba said:

> We learned during SMASSE "training" how we can demonstrate that movement of ions using some kind of indicator from a [red] cabbage. And then we set an electric circuit and then we see movements of ions by color, by flow of color. And that makes it very interesting to view it with the students and they are encouraged to even see science as being very real.

On organic chemistry teaching, Saba was aware that his students had enormous practical experiences on organic processes and products. Saba used his students' practical experiences on organic substances to teach the organic chemistry unit. The students knew more about the local brews found in their local communities. Some of his students even knew how to prepare them in their homes. Such processes were important when Saba was teaching alcohols in organic chemistry. As Saba put it:

> …when we are dealing with a topic like alcohol, students have their own experiences at home. They know how "busaa" is prepared at home. “Busaa” is the name used for our local brew in our country, and yet we teach this one in our laboratory about alcohols, separation of alcohols.

Saba had improved on his organic chemistry unit lessons implementation by having his students visit local breweries. The excursions made the teaching of organic chemistry real and the students were able to relate what they learned in school with what they came across outside school. Saba added:

> …are encouraged that we make this teaching real, I have had the chance now to even request the school administration to give me a chance to take students to a brewery. I am here saying that the principal also thought that I have to visit Kenya breweries where most of these concepts were made very clear for us.

Saba taught the periodic table using the charts purchased from publishers. He was able to buy periodic table charts from school equipment production unit (SEPU). Saba used the charts to discuss the characteristics of elements within a particular group and across the group. He was also able to relate the behavior of each particular element by just looking at them in a group. He ensured that his students were able to visualize the elements in a particular group downwards and that they elements had certain kind of behaviors. As he taught the periodic table, Saba ensured that his students were able to note that in a given group, the elements had similar characteristics. He felt that he “benefited greatly from the charts and the teaching of the periodic table had become real by use of these particular charts.” In his teaching of the periodic table, Saba ensured that he involved the students in relating the behavior, the properties of the particular elements and make appropriate conclusions about the characteristics of elements in a particular group.

The SMASSE project: Issues for considerations by the planners. Saba argued that as teachers who had joined "the SMASSE project, and which started very well with a lot of enthusiasm among science teachers, everybody wanting to join and struggling to join" the in-service planners ought to have found a way to select teachers. Saba also observed that the "teachers had a lot of hopes in the project and it picked on very well." However, the promises made to the district in-service educators were not fulfilled. Saba argued that they were promised that after three years, and later another year was added, of in-service and educating their colleagues at the district level, they were to be promoted to the next teacher grades. As one of the district in-service educators, Saba was disappointed that they were not promoted despite their dedication and contributions to the project. He felt that the SMASSE planners ought to have kept their promises if teachers were to take them seriously on what they said. On the promotions promises, Saba said:

> …it was to start with district "trainers" after completing the three cycles, the district "trainers" were to go to a higher job group and if I remember the way we were told this was to be done by July of last year (2003). But as of now I am not aware of any teacher who has been promoted to that effect and yet we were through with the three cycles.

According to Saba, the district in-service educators were educated at the national level and later more were to be absorbed at the national level because the project had expanded. He felt that "those who were to be absorbed should be people of either higher qualifications or people who were with result oriented." On the qualifications of the in-service educators at the national level, Saba said:

> …the people at the national level rather to say they could be for example degree holders. That means they are all now at par. Then if there is somebody to be absorbed to the national level then this person should probably have higher qualifications in the sense

> that this person has probably if it is a degree that we talk about higher qualification could be like master's level, Ph.D. Level and all that. Or it can even be in terms of experience, somebody who is more experienced in the field in terms of teaching or even somebody who has performed well at some levels. So that at least there is an edge over the others.

Saba expected the national in-service educators to be teachers "who had performed very well in their schools and there was evidence to that effect." The in-service planners would also recruit educators from among the district in-service educators who were familiar with the SMASSE in-service education courses. But unfortunately for the district in-service educators "a number of very new people brought to the national level, some with probably two years experience in teaching in schools." As Saba put it:

> I am a district "trainer" and I was there and I have experienced this myself. So while we were there we saw very young personnel who had just been in the field like it cannot be more than two years.

Saba argued that "experience was equally very important for absorbing people at the national level." The district in-service educators were likely to be confident with people who had something to offer them from their wide experiences in the profession.

Saba felt that the SMASSE project had given them a raw deal in terms of the amount of time they invested in the project. He argued that teachers who opted to pursue master's degree courses in the local universities had an advantage over those who went to be educated as in-service educators in the SMASSE project. He argued, further, that after two years' time, those who were pursuing the degree education, finished their courses and were recognized by the employer on presentation of their certificates. The district in-service educators were involved in the project for five years, had no certificates to show their contribution to chemical education, nor were they recognized by the authorities in any way. Saba thought this to be "a bit discouraging" and suggested that "as much as the educators are being educated let them be recognized."

In the cascade system of in-service education, Saba felt that the district in-service educators were the core of the project. In Saba's view, the SMASSE planners ought to seek information from the district educators as they were the ones on the ground. As Saba put it:

> …We have implementers at the national level. We also have implementers at the district level who are actually the district "trainers". These are the people who experienced the "training" at the district level and they should know a lot when it comes to "training" at the district level. So these people are very important people at least to get information from them about implementation of this particular project. So what I would like to say is that the national office should give opportunity for sharing, for discussion with these "trainers", so that there is flow in terms of implementation of this particular project.

Saba seemed to suggest that the SMASSE project planners ought to involve the district in-service educators in decision making than having the national team doing so about teacher in-servicing in the districts.

Role of the district in-service education resource center in school science education. Saba's school was the district SMASSE in-service education resource center. He observed that his school being the resource center for the project they had "been able to benefit from the project." Saba argued that all materials for the in-service education in the district were kept in his school, including the chemicals and equipment for teaching and learning the sciences. His school was allowed to use the materials. As an in-service education center, the materials and equipment were available for other schools within the district to use. The district schools had opportunities to have their students perform experiments at the center "whenever they requested for a particular experiment." Saba said that his school was surrounded by "small" schools with inadequate provision of science facilities. The center played an important role as it provided the neighboring schools with opportunities to perform experiments they wished to do. Saba said that they had informed the neighboring schools that the center was open, and whenever they went to the center, they were welcome to conduct any secondary school science experiments they wished to perform.

However, the center was located about four kilometers from the main road. Communication might not have been one of the best because the school was connected to the main road by a murram road. During the district in-service education sessions, the teachers were accommodated in school and those who came from nearby had opportunities to commute from their places. However, Saba felt that Gucha district was a diverse district with so many schools. He suggested that more in-service education centers should be opened to enhance the teaching and learning of secondary school science, especially chemistry that was being done by all students in the district.

Nane

Teaching background. Nane had taught, as a professional teacher, since1987 but had also taught as unqualified teacher in 1984 and 1985. He attended a two-year pre-service teacher education course between 1985 and 1987. On graduation in 1987, he was posted to Riomosa secondary school where he taught for six years before he was transferred to Okiki secondary school. He taught at Okiki for two years and in June 1997 he again transferred to Rigwa boys' high school, a school in which he was still teaching in. In total, Nane had taught for sixteen years as a professionally qualified science teacher.

During his ordinary level education at Seme secondary school, Nane was influenced to like chemistry by his chemistry teacher, Mr. Buseinei. Nane said "I had a teacher in chemistry who actually influenced me to be a teacher. Of course I really enjoyed his teaching." Nane opted to become a science teacher after his advanced level education. He had not qualified for university education and had to join a middle level college. He attended an interview to recruit college students that was conducted by the Kenya Science Teachers College. After passing the interview, he was admitted to the Kenya Science Teachers College, where he was educated to become a chemistry/biology teacher.

At the Kenya Science Teachers College, Nane was educated for a diploma in science education, which took two years. The chemistry content taught at college was slightly above the advanced level. For the two years at college, they were taught chemistry content and then subject methods in chemistry. They did peer-teaching, micro-teaching and finally teaching practice for three months before they graduated as chemistry teachers.

Before the SMASSE project, Nane had no problem with the chemistry content. For his chemistry instruction, he prepared lesson plans, prepared the manual for the experiments in class and used the Ministry of Education’s recommended secondary school chemistry textbooks. According to Nane, he taught his chemistry lessons based on the methodologies he had been prepared in during his pre-service education. He prepared lesson notes and occasionally performed teacher demonstrations, when students’ class experiments were not possible. Nane said he did the week's demonstrations as his students made the observations. He wrote the experimental procedures/instructions on the chalk board for the students to copy in their notebooks and proceeded to perform the experiments. According to him, this approach sometimes wasted considerable amounts of time for learning. He sometimes provided his students with written materials during practical sessions for the students to be able to perform the experiments on their own and within the class time.

Nane joined the SMASSE project because the chemistry teachers, who were in job group K and above in their district, were to be interviewed to become district in-service educators. He was one of those teachers short-listed for the interview. After the interviews, he was one of the four chemistry teachers selected to attend the national in-service chemical education at the Kenya Science Teachers College. The in-service course sessions were always conducted for ten days. Nane participated in the SMASSE in-service education for the five years the project was being piloted.

The major benefits Nane received from the SMASSE in-service program. Nane thought that the SMASSE project had helped him to refresh himself on some chemical education issues he had been overlooking, such as conducting small-scale class experiments. He also benefited from time management of chemistry practical sessions in school. He prepared his instructional materials in time and prepared how he had to implement his lessons. As Nane put it:

> What I benefited as a person was from actually preparation and wastage of time. I realized that I could waste a lot of time during the preparation because I could wait until games time then that is the time I give them the instructions and materials. But we realized, after the SMASSE, that we prepare and give the materials. Instructions can be given earlier so that the materials are prepared earlier enough. Then after that the students have to come, they are given the materials and they start working in their stations without wasting time. So, after that I think I will say on wastage of time, I have benefited.

Another benefit from the project was the incorporation of the lesson notes in the lesson plan format. He accommodated students' own questions from the instructional manuals. He answered the questions through student involvement in class discussions; Nane added:

> I have benefited and somehow preparation of lesson notes which now go together with the lesson plan, they are put together. So we give lesson notes together with, as we teach. So there isn't actually much wastage of time when we teach because at the same time we are giving notes. Then somehow through the manuals or instructions that we give the students are also able to even come up with their own questions on their specific topic and we can discuss those questions together during that lesson.

On what Nane learned from the project that he did not know, he said "there isn't much I learnt that I didn't know only that I was only reminded of what I might have forgotten." From Nane's discussion, it appeared that the in-service education programs were beneficial to him in terms of reminding him the chemical educations issues he had not been dealing with or forgotten. He did not gain anything on the chemistry content but had improved on his teaching skills.

SMASSE's influence on Nane's chemistry unit lesson designing. Nane found the SMASSE project format-oriented lesson plans simple to prepare because it did not involve many requirements. He said:

> Because with the content you know you have, even if it is the introduction, you can write the introduction and write what you would have to say. And therefore, the subtopic is already there and the notes that you are going to teach on that are already in the lesson plan. So at least it helps you, it induces you to prepare one without much struggle.

Nane continued to prepare his lesson plans based on the SMASSE in-service education format they had designed when attending one of the national in-service courses. He had not made any changes on the lesson plan format they had agreed on during the in-service sessions.

Implementing chemistry unit lessons following the SMASSE in-service programs. Nane talked about how he implemented his lessons on the periodic table, "mole concept", electrochemistry, and organic chemistry. Below are his views on his lesson implementation following his SMASSE in-service education courses. Nane felt that the periodic table had always been a problem to teach. However, when teaching the periodic table, Nane initially ensures that the (periodic) table is drawn on a Manila paper, especially for the first twenty elements in the periodic table. The prepared periodic table for the first twenty elements was then placed in class for the students to always observe and refer to. He said that he "always involved the students in writing their periodic table using atomic numbers, which of course we have to write the electronic configuration there and all that becomes maybe their own periodic table."

On the "mole concept" Nane involved his students in doing more questions and more experiments on molar solutions, and chemical equations. Nane argued that the "mole concept" required a lot in terms of calculations. "And some of the students fear anything to do with math, anything that requires calculations." The teaching of the "mole concept" was sometimes feared by many because of their attitude towards calculations. Nane said, "…when it comes to this "mole concept", actually what makes them have problems is when it comes to calculations. Otherwise that is why I was even saying…we have some teachers who actually even fear calculating."

To improve the teaching of the "mole concept" in schools, Nane argued that teachers ought to be thoroughly prepared on this topic right from teacher education colleges to avoid the multiplier effect of their negative attitude towards the teaching and learning of the "mole concept". As Nane put it:

> So when it comes to this "mole concept" they already have that problem of calculation, so that is why I was saying that the background. Like if this "mole concept" was taught well maybe at college, we expect these teachers when they come to school, they should not have any problem with that. So those ones who had problems with the "mole concept" in their colleges, they will transfer that one to the school.

In organic chemistry, Nane realized that he needed to change teaching it as a last topic in the syllabus in Form Four. As he said "so with the organic chemistry we have liked to teach it earlier." He had started teaching it in Form Three. This ensured that as he continued teaching chemistry, his students were aware of the organic compounds early. He argued that because of the large number of atoms that are involved in organic molecules, students feared even writing the chemical equations for organic reactions. About students' apprehensions on organic chemistry, Nane said:

> The fear that they have in the writing of chemical equations, actually the large number of atoms, maybe if it is ethanol, you know it has two carbon atoms and you have the H and whatever. Then when it comes to its structural formula, they can not relate that structural formula to the chemical formula, the single atoms. So when you enlarge it, when you open it looks a bit larger than the formula that they had expected.

He covered work on organic chemistry early enough before he started to teach electrochemistry and other topics in Form Four. Nane planned for simplified lesson introductions and simple class experiments in his organic chemistry classes. A simple but powerful lesson introduction made Nane's students to have interest in the topic before he covered more content in the area. As Nane put it:

> …with the simple experiments that we do in class, the organic chemistry seems to be a bit simpler as we had not expected. Now of course the knowledge of SMASSE somehow has helped in trying to simplify the other topics especially during the introduction of a topic. We have to maybe involve the students, I give them a few things to do before we introduce a topic which of course make them have interest in that topic before we start talking about content in it.

Prior to the in-service education programs, Nane used to teach organic chemistry without much reference to the locally available materials. However, focusing on the locally available organic substances that his students were familiar with had made the teaching of organic chemistry simpler than he had expected. Nane said:

> …we have been avoiding the use of these locally [available materials], these plastics. Now when you go there, you burn that plastic, they will be able to see the fumes coming out. Then of course you can even prepare a few using urea. You can prepare it in the lab. So when you do it like that they feel it is a bit simple.

Reference to what the students had covered in other topic areas was useful in assisting the students understand the organic chemistry concepts. Nane took the periodic table as one of the pre-requisite knowledge areas that students needed to learn about the chemical formulae and reactions involving organic compounds. As Nane put it:

> When it comes to organic chemistry, you know they tend to forget about what they learnt in the periodic table and the valence of carbon. So when it is in organic, it is as if it is something new. So at least when you teach this organic chemistry you have again to talk of the valence of carbon and refer them even to the periodic table that they had done so that they don't see this organic chemistry as something so new. So at least when it comes to now writing the reactions like now when you have an ester reacting with maybe sulfuric acid. You know you can talk about it as being a neutralization reaction as it is done when you are reacting let's say sodium [hydroxide] and an acid.

On the other hand, Nane thought that some teachers had problems in handling the organic chemistry content. On his part, he felt that he was adequately prepared on the chemistry content during his pre-service teacher education at the Kenya Science Teachers College. According to Nane, it was the students who seemed to have difficulties to learn organic chemistry but not because of his pedagogical content knowledge level. Nane said:

> It is as if the teachers when they are in college maybe they could also be having problems in these topics, especially on organic chemistry. I don't know whether they are not taught properly in colleges or not. But the way we were taught in our college, that is The Kenya Science Teachers College, I have never found any problem in the teaching of these topics only that maybe the background of the students that these topics are difficult. That makes them not to grasp the concepts as they are.

Nane taught electrochemistry as a Form Four topic because it required prior knowledge of other topic areas. The students needed to know about redox reactions and how to balance chemical equations. They needed to understand the “mole concept” and know the effect of electricity on substances. Through student-centered activities, Nane taught electrochemistry. He was, however, more involved in teaching electrochemistry through improvisation of teaching and learning materials. As he put it “in electrochemistry, through improvisation, at least we can make use of some simple and locally available materials like the plastics that we have around to make the cells.”

Changes Nane made in the implementing chemistry unit lessons. According to Nane, he was not making many changes in his chemistry unit lesson plan implementations. He involved the students more in his chemistry lessons compared to his teaching prior to the in-service education program. Nane said:

> …and when it comes to now the actual teaching in class of course previously we never used to involve the students in, I mean the students will not even participate in the lesson. So right now of course we give priority to students to participate in class so that whatever comes out comes out as a thing that they have internalized. Otherwise that is what I could

> say so that when they participate they benefit more. Actually they learn more when they participate in the lesson….

On how the students were more involved in the chemistry lessons, Nane said that he now made his students to take part in class investigations. As Nane commented:

> …of course if it is a class experiment, they have to come up with their own procedure, how they carry out that experiment. Of course they will even now, if you give them time, also to see how best it is, which apparatus they are, to use, handle and see how they can arrange those apparatus in order to carry out that experiment.

During the class investigations, Nane played the role of a supervisor. He went round in class, as the students did the class investigations, to evaluate the students' progress and assisting the individual students or groups. On his role during the students' experimental work, Nane said:

> …the role of the teacher is maybe to go round and see what they have, the kind of procedure that they have. So once you go through that you can see what they have written and make a few changes on what they have prepared because sometimes they can write a procedure which may not give them the results that you expect. So you have to go round and make a few changes on what they have.

Nane made changes in his lesson plan implementations during his student-centered activities to ensure that his students benefited from their experiences. He had also to ensure laboratory safety during the class investigations. On why he made changes during his teaching sessions, Nane said:

> The reason is that to make them actually arrive to the expected result, otherwise somehow they can carry out on the experiment using that procedure and you might cause an accident. Some of them can even burn or some of the experiments can explode if not mixed well, if not carried out well.

Nane made other changes during his teaching when he found his students lacked some prior knowledge on the areas he taught. Nane said:

> …of course when you go to class you find that the topic you are going to tackle, some of the students are not ready to take in. That is maybe they don't have earlier knowledge of what you are going to teach. So somehow you have to maybe start talking of what you have done previously so that you bring them to the topic that you want them to learn.

Student difficulties in understanding the concepts taught are never ignored by Nane, especially when they lacked some understandings on previous work covered in the curriculum. Nane had to make changes in class to accommodate his students' questions and address their difficulties. As Nane put it:

> …somehow you find like when you go to class, maybe you are talking about energy changes, then somebody is asking you about heat of vaporization, what is this? And maybe that is what you had done earlier, so of course when you realize that you don't just put off that student. So somehow you have to change and start talking of this heat vaporization. You define then from there you can to maybe what follows so that this student gets a sequence of things from the easier ones to the difficult ones.

However, the individual student questions are posed to the rest of the class so that as Nane answered the questions all the students in class are involved.

> …like now if there is somebody and asked, a boy has come and asked maybe "Mwalimu" (teacher) I don't know what you mean by this and this, of course you involve these other students it will mean that maybe you would like to have some of the boys answer him. So that by doing so, you would have actually more or all the students [involved]. They will start [by saying] something about what they know about it. So as they answer the boy, then you can clarify and then you go on.

The changes that Nane made during his chemistry unit lessons were meant to ensure that his students followed the concepts taught in class. His changes were more student-centered as Nane supervised or guided his students in learning activities.

The SMASSE Project: Issues for planners' considerations. In general, Nane perceived the SMASSE in-service education program as a good project especially for beginning teachers. However, Nane felt that there were some issues that the SMASSE in-service education planners were overlooking. The overlooked issues were likely to impact negatively on the sustainability of the in-service education programs at the district level. Nane argued that the planners should know that as they carry on the in-service courses, some of the in-serviced teachers do not implement what they have been in-serviced in. He suggested that there ought to be follow up activities by the in-service educators to ensure that teachers had keen interest in the SMASSE project activities.

Nane argued, further, that teachers were seeing the project as wasting their time because there were no compensations for the times they were putting into the project activities. Other than improving their teaching skills, district in-service educators would have liked to see their efforts rewarded materially or through promotions. Nane said:

> And what they should also know is that, maybe these, the teachers themselves, looking at this project as a project that is wasting their time somehow in that there is no much gain especially when it comes to material gain or in their promotions. So when a teacher has gone through this SMASSE project maybe at his mind is thinking of getting a promotion and maybe getting more money, something like that. If they [can be recognized] I mean of course in terms of grade. But so far it has not really helped many of us.

The district in-service educators were involved in the project activities for five years. They made many sacrifices to the success of the project implementation at the district level. The SMASSE planners seemed not to have considered the welfare of the district in-service educators. Promises to these in-service educators appeared not to have been honored. In this regard, Nane said:

> …the promises that were given to teachers that they were to go abroad….It has not happened to most of them, and most of them are actually feeling that they are wasting their time. Then it comes to districts, like ours in our district Gucha, I feel that the stakeholders have not been involved so much. Many of them feel that they are not gaining out of the project. So they are not really supporting the project at all in the way I am seeing. So they should actually come up with….a plan…and make these stakeholders to be aware of the benefits of SMASSE and let them be involved in this project.

It was not possible for the project to take all district in-service educators for further education abroad. Nane expected to be taken for further education after serving in the project for five years. However, when Nane was challenged to elaborate on what he meant that teachers were to be taken for further education abroad, he responded:

> You know they had said that these “trainers” at one time they will be given scholarships maybe to Japan and do some more courses in that and of course much also to increase their knowledge in the sciences. But then the way these people go, whoever has gone is as if there is, you know they don't take them as we had expected. You know we had thought that after “training” at national level, we could have been taken to another level for further “training” but so far it has not happened.

The SMASSE planners left the district in-service educators in great confusion concerning their mobility in the profession. As the pioneers of the project, Nane had great expectations for the project in-service educators. He expected that their participation and contributions in the project implementations were to be recognized like any other person who pursues a higher certificate course in teacher education. It seemed Nane was not comfortable with the recruitment of the new personnel that later joined the national in-service education center to educate him and his colleagues. To him, the new recruits were young, inexperienced and had little knowledge on the SMASSE project activities and in-service education curriculum. As Nane put it:

> …when we joined this “training”, we expected to be given first priorities, especially when it comes to promotions. Now it so happened when the headquarters wanted some other “trainers” to join the headquarters, we realized that the advertisement they had given said that the district “trainers” should never apply. So it was as if the “freshers” were to apply. So we were barred from joining the headquarters. When at the same time what I want to say is that we have people who have more experience in the teaching and they are never in the SMASSE project. It so happens that those ones with less experience in the teaching [are the one] who are “training” these people with a lot of experience in the education system.

During the initial recruitment of those to be in-serviced to become district in-service educators, many experienced teachers, with many years of teaching, did not apply for consideration. At the district level, all chemistry teachers were supposed to be in-serviced regardless of their grade level and experience. This was a problem to Nane who had to in-service some of his colleagues who were either at a higher teacher grade level or had higher academic or professional qualifications. Nane commented:

> So even the district “trainers”, I think there was a time we were in problems because of the type of people we were “training”. Some of them were older than us and at the same time they even had better education level. So in that case they could not even be ready to be in-serviced. They will always rebel.

For this group of teachers, they were not looking at one’s enhanced knowledge in in-service teacher education, but the original academic or professional qualifications of those who were in-servicing them at the district level. Nane added:

> So you see with them they were looking at the kind of education. You know they are looking, they are not seeing the SMASSE has something, that after going through those “training” that you could be able to “train” them. Because they were only looking at the education level so they were not actually looking at what you have been “trained” in the SMASSE project in-service.

In Nane’s view, the SMASSE project planners ought to recruit teachers with higher qualifications to in-service the district in-service educators. The criteria that the national SMASSE project planners used to select the national in-service educators did not augur well with the district in-service educators. Nane argued:

> …we have cases where maybe a colleague of mine, I went to college with him and here he is now after "A" level at The Kenya Science [Teachers College] now being the national “trainer”. At this point, I feel he has not gone to any other course maybe he has not gone in for further education, so when you find him there it is as if you are at the same level. So whatever he is doing you feel you also know. So there isn't much change.

Initially the district in-service educators were not supposed to apply for the vacant positions for in-service educators at the national level as the project expanded. The advertisement put in the local dailies informed the district in-service educators that they did not qualify to apply, perhaps to ensure that the capacity building at the district level was sustained. However, with time some of their colleagues from other districts, with no any further education, found their way into the national in-service center and were now in-servicing them during the fourth cycle of the in-service program. This arrangement did not augur well for many district in-service educators, including Nane himself. As Nane put it:

> Then here is a case some of the national “trainers” [whom] we started “training” together with them. With them they have now been uplifted. They are now the national “trainers” when we are still district “trainers”. So, when you go there, you were at the same level as concerns the SMASSE project, but he has now gone ahead being the national “trainer”. So I don't know which criteria they were using.

The district in-service educators ought to be teachers of integrity if they have to command great respect from teachers they in-serviced at the district level. Nane was of the opinion that those who in-service others ought to be teachers who deliver great results in the national examinations from their stations. As Nane put it:

> …you find a person from a school which has never appeared or which has always had problems when it comes to examinations they are the same people now “training” you. So you tend to feel that he has nothing to tell you. So those are the people who should not be involved in the “training”.

On the issue of delivering in one’s school, Nane argued that it was the number of students one had achieving high grades in the national examinations regardless of how much the student gained from class. Nane said:

> You know in Kenya, somehow the system is exam-oriented. Otherwise when you have good results in your subject, maybe many of your boys or your students have got good grades, then that is the time you are told you can deliver. Otherwise you know we don't really consider a person, who delivers by maybe looking at what the knowledge all the students that have gained but we look at the outcome after they have done the exams.

Assessing a chemistry teacher’s success on the students overall achievement score in the national examinations should not be the only criterion for identifying great teachers. Chui had many district schools with poor provision of science facilities and students who had low achievement scores in their national primary education examinations. A great chemistry teacher ought to be looked at from the amount of value he/she added to the students he/she taught. Nane said:

> The students' background also matters...we have some schools with very poor students. But if a good teacher can, maybe have a good result out of that poor student, then, we can always say that teacher is a good teacher, he can deliver. So if you can actually get a

> person with very low marks, let's say in sciences when he did his KCPE but then when he joins in secondary he finally comes up with an "A" we could say you have done a good job.

In-service teacher education is an important component of an education system. Successfully run teacher education programs are likely to have a great impact on student achievement in secondary school education. The SMASSE project had improved the teachers' teaching skills. Teachers had started to incorporate more student activities in chemistry unit lessons. However, the sustainability of the SMASSE in-service education in Chui district appeared to be under a great threat from the school heads that were not keen to contribute towards the project activities. The problem was even more critical as the student achievement scores in the national examinations in the sciences had not significantly improved to justify SMASSE project's existence for five years in the district. As Nane stated:

> Most principals in schools in Chui, they are not ready to give out their share, that is, the money that is required to maintain the project. And what they say is that they are not gaining, maybe their schools are not involved in the SMASSE project especially some of the teachers have not gone for the "training" of the project. So that is why they feel they are not gaining at all. And they had hoped that after the project they could have had good results in their schools but not much has really changed because in Chui we are always the last. And the exam results have not been good most of the time.

Records at the national SMASSE project office indicated that the project had been implemented successfully in the districts. It was through the recommendations of the evaluation team that the project went national with effect from May 2003. However, Nane argued that there were some teachers in Chui District not in-serviced by the SMASSE project. On whether there were teachers who had not been in-serviced in Chui District, Nane responded "yeah…we have, like now in this school we have so many. They have not been in-serviced in the SMASSE project." As to why these teachers did not want to be in-serviced, Nane added "what they say is that they are not ready because they are not seeing the reason why they should "train". So they have not actually “trained”. Nane, further, said, “like now somebody says I mean at this age why should I go to ‘train’ in SMASSE. So the administration is ready to sponsor them, but the teachers themselves say they don't want to join.”

Although the school administration was willing to sponsor teachers for the in-service education in Nane’s school, some argued that they did not see the need as there was nothing for them to learn from SMASSE Project at their advanced age. SMASSE planners have to address such teachers as they continued to teach in schools irrespective of their age and experience.

From the discussion, it was evident that Nane wished that the authorities recognized their efforts and contributions in the in-service education. In his parting words he said:

> We need to be somehow given more morale of teaching and this one of course it can only come through promotions. So as we go on teaching in schools without promotions we may not do much. We need to be appreciated somehow for the work that we do. And the appreciation maybe through promotions.

Nane also wished that the public school teachers’ employer in Kenya would start recognizing higher academic qualifications for higher teacher grades. The Teachers Service Commission (TSC) seemed to only recognize the P1, diploma, and undergraduate degree certificates as the professional qualifications under which they employed and promoted teachers on. For teacher education to be meaningful, the TSC ought to consider masters and doctorate qualifications in the teachers’ grades system. Nane said:

> …as we have in our teaching profession, it is as if when somebody goes in for further studies like now I had a case where somebody had done masters but his masters was not recognized by TSC in terms of the grade. I know it could even make others not even to go for further studies. What I have come to learn maybe those ones who had maybe P1 and he has gone maybe for a degree that one can actually benefit because he is now given a grade of being a graduate teacher. But for those ones who do masters there isn't much and yet they have done a lot.

Teachers’ morale needed a boost through further studies and recognition by the concerned authorities.

Tisa

Teaching background. Tisa had taught for 20 years continuously since 1984. He had mainly taught chemistry and at times mathematics. He had taught at Nyasigo high school during his student teaching practice. As a professional teacher, he had taught at Amaraga and Nyansaria high school where he taught chemistry up to advanced level. He had also taught at Nyabioma girls' high schools. At Nyabioma he taught both ordinary and advanced level chemistry. During his stay at Nyabioma he saw students' achievement in chemistry improve tremendously, in which the subject became one of the best performed subject in school. He said:

> I especially noted when I was in Nyabioma but chemistry changed from being the worst subject to being the best subject. For two years continuously we were taking awards for being the best science department and mainly my class was taking those awards.

Later on Tisa was promoted to head Tichi secondary school, where he still had time to teach chemistry. He observed:

> …in Tichi, where I was again a Headmaster…I could still find time to teach chemistry and especially prepare students for exams where in most cases I would find that the teachers who were teaching those subjects had less experience. So I would bring my previous experience to prepare these students for exams.

At the time of the interview, Tisa had been transferred to Takabare secondary school as the new Head. At his new school, he still continued to teach chemistry. He said:

> I have Form Three lessons, chemistry. So I have taught all the topics of chemistry. I am very good when it comes to electrochemistry where in most cases even my colleagues have sought my assistance. I am also good in teaching the "mole concept", and I am also very good when it comes to teaching organic chemistry.

He was prompted to be a chemistry teacher because as a student he loved chemistry. He joined the university to pursue chemistry because he thought it was the best subject to pursue. He found chemistry teaching interesting and enjoyable, especially when conducting class experiments. As he put it:

> I just found that I loved chemistry as a student and when I went to "train" in the university I thought it was the best that I would choose. This is because as far as I was concerned it is a more entertaining subject to teach. It has…you found more examples to teach when I am teaching chemistry and to carrying out practicals is something quite enjoyable.

Tisa was educated to become a chemistry teacher at Kenyatta University. At the university he did many laboratory chemistry experiments in addition to the content they covered in theory by various professors. He was prepared in chemistry subject methods and how to be an effective teacher. As he said:

> …we used to have practicals in the lab. Other than that we also used to be given content where we learned a variety of topics by various teachers. And therefore we were also teacher-made in chemistry education by somebody whom I thought was quite competent and who told us how to go about for example teaching in the laboratory.

Prior to the SMASSE in-service education project, Tisa felt that his teaching was good. He had had opportunities to attend seminars on how to teach chemistry. Some of the seminars were being conducted by the British Council. Tisa said:

> I would just rate myself as being a good chemistry teacher even before I had that SMASSE in-service. This is because before I went to SMASSE, I had already had some in-services from various people, one of them being that one of the British Council. The only difference was, before I met people from the British Council, my teaching was a bit boring. I would at times get involved in making things work, in giving out the content at the expense of making the students [or the lesson to come by] and…but after getting this "training" of the British Council my teaching changed tremendously.

Tisa had rated himself as being an excellent chemistry teacher prior to his involvement in the SMASSE in-service education program.

Reasons for participating in the SMASSE in-service program. Tisa observed that the SMASSE project came to his way by virtue of him being the chairman of the heads association at Chui District, where he was initially involved in the panel that was selecting people to be in-serviced in the SMASSE project. As a practicing teacher, he felt that he should also be one of those people in-serviced by the SMASSE project. He surprised the interviewing panel, of which he was a member, when he indicated that he also wanted to be interviewed for consideration as one of those to be educated to become district SMASSE in-service educators. As he put it:

> I surprised the panel by just turning aside from being a panel member into somebody who was being interviewed. So I took the seat of interviewee and I was to be interviewed by the panel. A colleague of mine changed from being a candidate and become a panel member. I become a student in that particular case somebody has to be interviewed.

It appeared that Tisa was a motivated chemistry teacher who wanted to make a contribution in promoting the teaching and learning of chemistry in his district.

The major benefits Tisa received from the SMASSE in-service program. Tisa said that what he had mainly learned from the SMASSE project was how to improvise teaching aids using locally available materials in schools. In reference to his chemistry teaching, Tisa said, "it also changed a bit when I also got the SMASSE project, which enhanced my improvisation skills. I became slightly better than I was in terms of improvisation." Tisa had greatly benefited, for example, "by learning how to carry out some of these dangerous experiments like burning of hydrogen easily and without much problem." Tisa, further, noted that he had also "learned how to improvise and make candles out of the local materials." Performing activities on the properties of gases using improvised materials and involvement of students had made Tisa's teaching easier and convenient on time management. As he put it:

> I also learned how to, for example get, extract some dyes from local plants. I also learned how to use some waste plastic materials as preparation materials for gases like when it comes to preparation say of oxygen, you can easily use the film cans, the plastic film cases, and prepare this gas. In which case once you have so many of these you can easily give each individual student to use and prepare these gases. It makes the study of the properties of gases easier and faster.

Other than enhancing his improvisation skills, Tisa seemed to have been comfortable in the other areas of chemical education.

SMASSE's influence on Tisa's design of the chemistry unit lessons. Prior to his attendance in the in-service education programs, Tisa prepared lesson notes that he used in all the parallel classes he taught in school with a few changes, if any. Tisa said:

> Before the SMASSE, I would at times go to class using my prepared notes which I had even used in some other classes earlier and make very few changes. But after SMASSE I learned to make my lesson everyday, even if I used old notes I would always have a new look at them and see how they fit, especially the class I am going to teach.

During the in-service courses, Tisa learned that "you can have your teaching notes properly integrated with your lesson plan. They need not be separate." On the SMASSE lesson plan format, Tisa commented:

> A lesson plan shows the class, it also has the topic that is going to be covered, it also has the time it is going to take and what materials that are going to be used. And the steps I carry when I am teaching. Then below that I have space for the notes, which have been written in short hand. These are the notes that I use and when I …these are the notes that I used to get the students also note down a few things as I teach.

At times, Tisa had to make changes in his lesson plan design based on the students' feedback when teaching. Giving a situation in which he had to make changes in his lesson plan design, Tisa said:

> …this is when I realized that the students did not have very good background about the particle nature of matter. And therefore I thought I should first of all give them this background before I proceed with the "mole concept".

Tisa occasionally made changes in his subsequent chemistry unit lesson plans. The changes made were to accommodate the unexpected student needs in class that Tisa discovered when conducting his lesson. As Tisa put it:

> …Occasionally when I go to class and I find that the students may not be with me, I at times change when I am there. For example, I went to a class where I wanted to teach "mole concept" but as I was introducing the "mole concept", I found that there was need for me to first of all explain what is the particle nature of matter? So I had to review with students the three states of matter and what are the differences that make each state to be the way it is. Once we teach that chemistry we now moved to the "mole concept".

In making the changes in his lesson plan designs, Tisa was greatly influenced by the reactions of his students in class. Sometimes his assumptions about his students' prior knowledge in a given area were higher than their actual level. The students' feedback ensured that he took care of the areas they were having difficulties in. As Tisa put it:

> …it is the class and the reaction of the students. If you went to class and found that the students do not understand a topic that is new, you need to explore those topics that precede this particular topic and see whether they have that background information. So that is what normally makes me change and then bring in this information and see whether they have found knowledge in the preceding topics before I move.

One way he assessed his students' level of achievement in class was through questions-answer method. Through the students' response, he was able to assess their understanding of what was being taught and make changes in his lesson design accordingly. On what he meant about his students' reactions, Tisa said:

> …when you are teaching and trying to get a feedback, if you found that the students are not giving you the answers, you know and when you are looking for feedback you ask questions that are related to the immediate preceding topics. If you find they are not able to answer, then you are meant to revise this. So the reaction of students in this case I mean how the kind of feedback I am getting from them before I proceed.

It seemed Tisa made changes in his lesson plans to accommodate his students' needs in the content area he taught.

Implementing the chemistry unit lessons following the in-service education program. The use of improvised materials and having student-centered activities greatly influenced Tisa's implementation of his chemistry unit lesson plans. In teaching the periodic table, Tisa found it necessary to make and draw charts. He also had, in most cases, used models, for example when talking about the ionic structure and when he dealt with the compounds that can be formed by various compounds. For instance, in the structure of sodium chloride, Tisa used the models to illustrate the crystal lattice of sodium chloride. Tisa said that he had had time to build up the periodic table with students, rather than just teach about the periodic table. He usually encouraged his students to build up this by drawing the circles (representing the atomic structures of various atoms) and the patterns that emerge from the circles before he concluded to them that what they build was a periodic table. He normally gave the students the task ahead to write down the electronic configuration of elements and the patterns that emerge. According to Tisa "that is when I tell them you have now built up a periodic table by observing the patterns that are coming up from those electronic configurations."

In the "mole concept", Tisa had always taken time to give practical examples to his students, especially when gave out the difference of having one mole of various substances. He always used familiar items to illustrate the "mole" concepts to his students. For example he used the nails, the big nails and the small nails to illustrate the concept of counting and relate it to the "mole" as a number that can also be counted. As Tisa said:

> Count twelve of them (nails) and find the mass (of each kind) and in this case much as the number is the same the masses are different. So I give this kind of examples to the students. So in this case SMASSE has made me give a practical approach to the understanding of the "mole concept".

In his view, the SMASSE project had reinforced his teaching of the "mole concept" to incorporate a practical approach and enhance its understanding.

In electrochemistry, Tisa had demystified its teaching by giving his students simple examples and experiments. He encouraged his students to attempt making their own battery using the examples that the in-serviced teachers were given when attending the SMASSE courses. A project activity he involved his students to perform was where he expected them to make a battery out of charcoal and sodium chloride with some charcoal rods, and some dry wood. The students had to find out whether the battery acted as the usual battery. However, Tisa said that as “much as it does not give a very big voltage, it at times shows signs and in that case the students are able to understand” the application of the electrochemistry concepts.

When teaching organic chemistry, Tisa provided models which he encouraged his students to use in order for them to have the 3-dimensional view of the organic compound molecules. When the models were not there Tisa encouraged his students to use “Plastocene”, which they made into various balls, and had them of different colors so that some represented carbon atoms, others oxygen and others say chlorine. The involvement of the students in making models of organic compounds using locally available materials was an innovation that made the teaching of organic chemistry interesting and enjoyable to the students.

In other chemistry topics, that Tisa taught using the SMASSE Project ideas was when explaining about the rates of chemical reactions. Tisa always gave examples from the ones used in the homes of the students. For instance, in teaching about sharing and bonding Tisa always gave examples of two farmers who contributed oxen to go and plough. And when he explained, say some elements being more electronegative than others, he gave “an example of elements that tend to attract or tend to take the electrons to their side more and leave the other one with a positive end as being like the selfish farmer who takes the two oxen and ploughs his farm leaving the other one without oxen.” According to Tisa, the students tended to understand the concepts involved when talking about the sharing of electrons in molecules such as hydrogen chloride. In such cases, Tisa always told his students “that chlorine is a selfish farmer who takes the oxen and leaves a hydrogen without any in which case there is a deficiency of electrons and therefore becomes positive, while the other one has excess of electrons and therefore becomes negative’. Tisa said that “in this case chlorine has got excess of these oxen, the bulls with him and therefore can easily plough his field while hydrogen can not.”

Tisa's approach to teaching was a result of what he learned in the SMASSE in-service courses that as much as possible they "should be able to use local materials and at times local examples to drive in points." Tisa's use of improvised materials when implementing his chemistry unit lessons was in line with the PDSI approach and ASEI movement that they taught in the SMASSE in-service programs.

Changes Tisa made in the implementation of his chemistry unit lessons. Tisa was able to make changes in his lesson plan implementation as his lessons progressed. He especially made the changes in his practical sessions. At one time Tisa had to change his instructions to a class experiment on rates of reaction when he discovered that the chemical concentrations used were making the reactions to occur faster than expected and students unable to collect data. He had to stop the students in order to have time to change the concentrations of the chemicals. As he said:

> …when you have given them the chemicals to react and they are taking time, you at times find that the reaction becomes a bit too fast, in which I have always asked them to stop. I change the concentrations of the reactants. I am giving an example of where I taught the rate of reaction using hydrochloric acid and magnesium and I found that the reaction was a bit too fast…because for the students to take the time I have to dilute the concentration of hydrochloric acid. The reason, in that case, I changed because I found that students were not able to take data. And therefore when I did that it was now possible for them to take data, take the reading and at the end of the experiment we were able to come out with the rate of reaction that [takes time].

Tisa used his previous lesson plan implementations to improve on the next lessons. As Tisa put it:

> …the only time I go to teach a lesson, I have always first of all, you have got to explore from the students and know whether what we learned the previous day was taken in. So I first of all ask them questions to see how much they got that, then I start giving them [all]. In fact it affects the current lesson to the extent that if I find that they could not have any information, then I am remaining now to repeat what I had planned for the previous day. Otherwise I can't go on without the students understanding what they have learned. They can not build on what they had learned earlier if it is not related to information of yesterday.

On how Tisa implemented the changes that he made in his chemistry unit lesson plans during instruction, he said:

> When I discover that there is something that I need to change as the lesson is on, first of all I would have asked the students to try and make their observations. If I find that whatever observation they are making is not correct, it has a problem, then I will ask them to give time and first of all I will try to ask to say where they think the problem is. As I am doing that, I may ask the lab assistant, for example, to make changes as I engage the students in trying to find out where the problem might have been. And once say the solution has been diluted appropriately, then, I ask the students now to try using this specific solution and see what changes it could give. And the concentration I give in the second place is the one I believe will now work better but I make the students that is also to try it and see whether it is any different. That is how I go about making those changes.

Tisa, further, engaged his students on discussion activities as to why the experiment they were performing was not giving the expected results. By so doing, Tisa was able to involve his students in activities that made them to understand the nature of science. As Tisa put it, he involved his students in:

> …the discussion about why it failed, for example, so that I ask them questions why do you think it did not work. And then thereafter lead them into getting reasons why the experiment did not work. And so I try to encourage them to take the next alternative with some hope that it will work.

It seemed Tisa involved his students on hands-on and minds-on activities as he made changes in his chemistry lesson plan implementations.

The SMASSE Project: Issues for the planners' considerations. Tisa thought that the SMASSE project planners had made some assumptions, which in his opinion were not correct. According to Tisa, the planners assumed that the teachers who went for the in-service courses were lacking in content. On what content he was referring to, Tisa said:

> The topics what we normally teach up to Form Four I believe that most teachers, Kenyan teachers, have very good grasp of those concepts. It is the way of giving them out which probably varies: how they teach it, how whether they are motivating enough for the students to understand, whether they involve the students [in learning activities].

Tisa felt that considerable amounts of time and stress was put on content and at one time he thought that the in-service providers were educating the teachers to acquire content. Tisa argued that “my observation is that those who were being [educated] might have even had more content than even the [educators] themselves.” In his view, what the teachers needed was to enhance their chemistry teaching methods. The teachers needed to be more active in preparing and implementing teaching and learning activities. They needed to involve their students more and improve their teaching by having relevant “examples, analogies, and activities to make a chemistry lesson a bit more lively.”

There was need for the SMASSE planners to “ensure that whatever that the teachers learned in SMASSE continued into the future.” Tisa felt that there was a tendency of educating teachers in an in-service course with no plans for follow up activities or supervision of the in-serviced teachers on what they have been in-serviced in. With no follow up activities, “the teachers are going to fall back to their old method of teaching.” Tisa argued that the chemistry teachers were thoroughly prepared during their pre-service education courses but with time they needed to be enhanced in their teaching skills. He suggested that for the SMASSE project to be successful, follow up activities by frequently in-serviced educators were necessary to avoid situations where teachers resorted to their old ways of teaching chemistry.

The district in-service educators also require supervision from the national SMASSE in-service education team for effective translation and implementation of the in-service education objectives. Tisa said:

> We should have the national “trainers” check what the district “trainers” are doing. And in turn after “training”, after the district “trainers” have “trained” the cluster “trainers”, they should also go and know what they are doing and this in turn will also check on others so that there is that networked kind of supervision. So that you know from time the teachers can be reminded and they can be evaluated. Currently as it stands the evaluation is done on those who “trained” in the district and is not extended to those in the cluster.

In-service education supervision would ensure uniformity in the implementation of the in-service materials at all levels of the school system. Tisa wanted the planners to note that the in-service offered, at all levels, was similar and all attendees ought to be given equal treatment when it came to recognition by the authorities. As Tisa put it:

> There is also that assumption that the district "trainers" give inferior "training" to the cluster "trainers" which is not. I think it is those kinds of transfer of all that they were taught in the national "training" to those in the cluster "training". So in future it should be made possible that if a cluster, somebody is "trained" in a cluster and has gone the four cycles he should be treated as being good as one "trained" in the nationals so that the chances of them moving are the same. If that happens then the teachers who have undergone SMASSE at whatever level will feel equal and they like that particular "training".

Tisa argued that "the keeping of the district "trainers" for four years and then at the end of the day they are given a certificate, it is not worth it." He suggested that the minimum the in-service education attendees for the four year duration ought to be awarded was a university diploma. The SMASSE project ought to have been attached to one of the local public universities to make the award of recognized certificates possible. This would have been one way of motivating the in-service attendees. Tisa said:

> So that is when they feel better. But as it stands now, there isn't any much difference between one who has undergone through the four cycles of SMASSE and one who has not in terms of treatment by our employer and by even, I am sorry to say, the SMASSE project planners.

The recruitment of those who joined the national in-service education center was questionable to those who were in-servicing their colleagues at the district level. In this regard, Tisa was not happy because of the confusion created by the SMASSE project planners. He argued:

> There is this rather unfair treatment on the SMASSE national, those "trained" nationally by the planners in the sense that whenever there was a vacancy in the national group, rather than get people from the district "trainers", they were getting them from schools that had not [undergone through] SMASSE. And the reasons where I don't know what they were but for them that was quite devastating because each time these people were

> going for any other cycle, they would find somebody new and somebody who look quite naïve in the "training" of SMASSE and that was quite discouraging.

The experience of people in the field should count when it comes to taking somebody to be a national in-service educator. Tisa argued that "we should not have...very new people [educating at the national] and whose qualifications the [in-serviced] do not know and [even] how they were recruited." He suggested that in future, the recruitment of the national in-service educators ought to be more clear and open to competition "so that the best get into those positions not just somebody getting being picked and taken there."

As Tisa, further, put it:

> …we are never told whenever we go to those cycles we are never told what qualifications one has. All that we see is that we find some "trainers" who look much younger, much younger than all of us who are supposed to be "trained". You know the impression we get is these are people who have come from the field very new. We do not even know their levels of education, they are never stated, [and] we are never told. So we should be fair to those who are "training"…be seen to have had superior qualifications. Those are the national "trainers". The district "trainers" have got a first degree, then, those should be able to have a second degree or when it is lacking somebody with a superior experience in the field and with results to support that fact that this is a good person.

On what he meant by having people who had results to show, Tisa said:

> …in this country we have exams that we give every year. So we are talking about these results. If somebody is coming from a school where chemistry is being done very well then this person probably can compete favorably with the rest even if this person does not have a second degree, he could be justified probably to be a national "trainer" because that could indicate that this person has got very good ways of teaching. And those could be useful in making these other people to become better teachers in class. That is what I mean by they start using results, the national results of KCSE (Kenya Certificate of Secondary Education).

Since the teachers' employer had not given any recognition to the SMASSE educated teachers, Tisa felt that the in-serviced teachers had enhanced teaching skills compared to those who had not done it. He said:

> The truth is somebody who has gone through SMASSE is very different, is quite different from somebody who has not. But then this is not shown when it comes to us being treated

> or being handled by our employer. The employer does not seem to get any difference and this can be quite discouraging. So in future, if SMASSE has got to be successful then we have got to treat these people properly.

Tisa was happy that the SMASSE project had gone national. However, he feared that the quality of in-servicing teachers was likely to be diluted, especially if each district had its own way of implementing it. On the quality of in-servicing being diluted as SMASSE in-service education was being implemented nationally, Tisa said:

> The quality of "training" that the teachers were being given during the in-services will not be the same; it will be of a very poor quality in the sense that there is no concentration. These people the national "trainers" may not be enough and these people do not have any other person who is already "trained" to go and do that in the in-service because this thing is now taking off at the same time for all the seventy districts in the republic.

Tisa argued that it was "unfortunate that those who were 'trained' by the national SMASSE unit were not being used to 'train' these people in other districts." Although the personnel in the national in-service education unit believed that they were able to implement the programs on their own, Tisa felt that considerable amount of time (in years) was likely to be wasted. He thought that the national SMASSE project team seemed to be in hurry to start the national in-service education programs. Tisa saw the implementation of the national in-service education programs "as a public relations exercise…and there were no safe guards, [and] there are no policies that have been given especially the new districts." It was possible that many districts did not know how to finance and implement the programs on their own. As Tisa put it:

> And rather than them use those who were "trained" earlier to go and probably teach these other people how to go about it. They have left each district to do its own thing. So the districts that did not have SMASSE are quite disadvantaged. They are quite disadvantaged and therefore I don't know. I am not seeing the kind of "training" that those who were initially "trained" at the national SMASSE unit got. It is not like these others will get the SMASSE. So SMASSE generally has been diluted and it will never be the same again.

From Tisa's discussion it was evident that the SMASSE planners should cater for the in-serviced teachers' motivation through recognition of their contributions and efforts.

Findings from Chui District Focus Group Interviews

Reasons for participating in the SMASSE in-service program. Sita felt that there was need for teachers to improve on their teaching skills in order to address the deteriorating performance of chemistry candidates in national examinations. In his argument, he said:

> ...after "training" in college, we were posted to schools where you continued teaching but the performance in mathematics and science all along used to be very poor. So as the program came in, I found it handy so that at least we could put our heads together with other science teachers to know why the performance was actually poor and what we could do to probably improve the performance especially in areas like attitude, which becomes so negative among our students.

Saba argued that there were several reasons as to why they had to participate in the in-service education project. Prior to the in-service programs, the participants used to teach chemistry based on the traditional methods they were prepared in during their pre-service education classes. There was need to change their approaches to chemistry teaching. Saba said:

> ...the traditional teaching methods, which we were using when we were "trained" in colleges...that is partly because that is quite traditional because in lesson planning and in all aspects usually the way we were carrying out experiments, the lessons in class, we had to change it because it was a bit traditional and we had to add into a new approach.

Through the in-service education programs, Sita and Saba thought that they would be able to enhance their teaching approaches in order to have more students interested in learning chemistry. As Sita put it "so we need to look at new approaches to teaching, probably the way we are teaching because what was making the students have a negative attitude?

The other reasons for the teachers' involvement in the in-service programs, was to interact with their counterparts teaching chemistry in other schools and districts. The interactions were indeed beneficial to the teachers. As Sita put it:

> Another reason is interaction with counterparts in the same subject, you find since we were from different districts, it helped me a lot especially when you find you are interacting with friends, the way they are teaching in their schools and most especially when we had to go to classroom situation because we went practically to the classes, we were doing actual class teaching and we as teachers would learn a lot from one another. The way they were approaching and therefore it helped me a lot.

There was also need for the teachers to be exposed to some instruments used in teaching chemistry that were not available in their schools. Where some of the instruments were not available the teachers were shown how to improvise them as they conducted chemistry lessons in schools. Sita, further, commented:

> Another reason maybe is the exposure to some instruments, which we have not at all in our schools. Some of the schools are young and there is some of the methods were improvised with some materials we have, which we did not use, so with that improvisation, which we learned when we were with colleagues, it helps a lot. And also as a teacher, we expected, I found carrying out that to be a [convenient] that is why I joined the program because I wanted to [surprise them].

Saba said that the local education office required all science teachers to attend the in-service teacher education courses. Saba stated, "…it was a requirement from the D.E.O's office, that is, the District Education Officer's office that science teachers be in-serviced. So being a science teacher I also had no option other than get involved in the project."

Participants' expectations of the SMASSE in-service program. Saba, who concurred with Sita, expected his participation in the in-service programs was to lead to improved student achievement scores in chemistry. He expected to be able handle chemistry content well through his enhanced teaching skills. He said:

> ...after we have finished the course we expected this to improve the results and have our candidates, the Form Four sciences which have been poorly performed previously. We also expected that since we have to learn new methods, we expected also to use the course because being a mere [problem] we are expected to learn a lot how to improvise some of the things we need, some of the droppers, some of the basic materials that we require in the lab and therefore reducing the costs.

Sita concurred with Saba as he argued that he expected the quality of teaching in schools to improve through the in-service teacher education courses. He also expected the attitudes of students towards learning chemistry to change because of teachers' enhanced teaching skills. As Sita put it:

> ...my expectations of the SMASSE in-service teacher education program was also that the quality of teaching was to improve through in-service "training" and that the attitude of both students and teachers was also to improve. And that we had government in conjunction with the JICA(Japan International Cooperation Agency) were to look at the issue of facilities which was hindering performance in schools so that at least a way could be found to provide these facilities to schools or some centers, "training" centers.

Saba also felt that the teachers were to be equipped with more knowledge on how to handle experimental work in chemistry. Saba commented:

> Also we expected all science teachers to be equipped with the knowledge after they underwent that in service course, the SMASSE in service course. It is something which was our expectation actually that these teachers once they get equipped, would expect to come out with good science experiments and then make it in the long [run].

Sita argued that he expected that the SMASSE project to target all science teachers within Kenya for in-service education so that all of them were reeducated. In agreement with Saba, Sita said:

> And we expected more schools therefore to be involved in the study of sciences because some schools have been feared to have a lot of students in science. But with the introduction of SMASSE, we expected more schools to join in and therefore get involved and hence more students coming out as scientists getting more for being "trained" on the science-oriented careers.

The participants expected that the in-service education courses were to lead to higher student achievement scores in chemistry.

Participants' expectations met by the SMASSE in-service program. The participants felt that their implementation of the in-service programs at district level was successful. The project had improved their teaching skills and were able to in-service their colleagues. Although, the in-service project had not impacted all the schools and teachers the way they would have wished, Saba said:

> ...for the district level, we have succeeded. We have actually started "training" at district level, which is a success. Also some of us who have actually been "trained", we are able now we have improved in our teaching way, our approaches. And some of the teaching, we are able also to "train" other teachers who have not actually attended the program. And through us, therefore, the district "trainers", we have also "trained" some cluster "trainers" who have been able to spread it although not as much as we would have expected but somehow it has taken off from that.

Saba's assertion about the education of teachers at the district level was supported by Sita who observed that:

> For instance, the "training" of science teachers, although we were "trained" at the national level, we have also been able to "train" teachers at the district level and also at the cluster level. And one thing which became clear from our "training" is that most teachers were able to confess that actually, initially they had a very negative attitude and this had infiltrated with the students so from there on they saw the need of changing their attitude towards the teaching of the subject.

The in-service programs had positively impacted on the teachers' attitude towards teaching. One of the schools, Saba's station, which was selected as a district in-service education resource center had been well equipped. This had given those schools with limited science facilities opportunities to conduct experiments using resources found at the center. As Sita put it:

> Equally some district centers in the name of schools we have been equipped with facilities, which is good, and other schools are able to go to these particular centers so they can be able to perform certain experiments, which probably they would not be able to perform in their schools. The SMASSE project is going national and so my expectation that the "training" be extended to all science teachers is somehow being met. So finally I expected the quality of teaching in schools is going to improve as we "train", as all science teachers undergo this particular program.

On the other hand, Saba felt that they had been able to have the stake holders such as school heads, parents, and the District Education Board (D.E.B) to invest in the in-service education program through contributions they made. As Saba said:

> ...all teachers especially headmasters, most headmasters have invested in the districts now, the district being a SMASSE district, they have invested and therefore they are aware and they are able to contribute towards that teaching, which is actually assisting…The D.E.B itself, the district education board, which is actually running the educational program in the district, is also aware of that and therefore the programs for it, say the parents are the stakeholders therefore are also partly involved.

The district was able to award the in-serviced teachers with participatory certificates. This was one way to motivate the teachers as recognition for the courses they had done. As Saba put it:

> ...the certificates for the three-cycles which have been issued that one at least [one expectation], which we have met and we are happy about it. At least that is how I would have expected this SMASSE in-service program's expectations to be met.

It is important to note that in a human capacity building through in-service education programs, the recipients of such courses ought to be recognized in one way or another for sustainability of the programs. At least, the project offered participation certificates to the attendees of the in-service education programs. However, one is left with a question, of what relevance were these certificates to the teachers' professional growth?

Participants' expectations not met by the SMASSE in-service program. From the focus group discussions, it was evident that some of the district in-service educators' expectations were not met but the SMASSE project. As Sita agreed with Saba on areas the project had not met their expectations, he said:

> …first of all I would like to concur and agree with him that the district "trainers" having undergone the 4-cycles, their efforts actually require to be recognized. Because for one these are people who have spent most of their time in the "training", there are their colleagues who did not "train" the SMASSE program and they joined other institutions of higher learning. Most of them have been able finish and they have certificates and have been promoted accordingly. So, those who are in the program, it is my feeling that I would liked that they could have been considered also for upgrading of some kind.

The issue of compensating the in-service educators on the extra times and efforts put into planning, preparing and implementing the in-service programs at the district level was very sensitive among the participants. In Sita's words:

> …district "trainers" have done a good job; they have "trained" with results, have gone to the fourth cycle in fact. They should be given fair and true promotions because some are old teachers, some have taught for a number of years, for twenty years teaching the same subject, they are now district "trainers", they are still in the same grade, they are "training" with some people who have taught about seven years, that is a big disparity. So, we would have liked it to give compensation for the "trainers", that they be given fair and true promotions.

Saba argued that schools should to be staffed with enough science teachers "so that the district 'trainers' can get adequate time to embark on the in-service education program." On the state of understaffing of science teachers in schools and the problem of dealing with unprofessional teachers, Saba said:

> In most of our schools, we are understaffed in the Science Departments, Mathematics, Chemistry, Physics, Biology, where teachers are not enough to handle those subjects. And you find in most cases you are either engaging "untrained" teachers, those ones who have finished some general degree from the university and therefore the government has not posted enough.

Schools were forced to hire unqualified teachers to teach the science subjects. This was an extra expense on the parents-teachers' associations, money which could be used in meeting teachers' daily expenses during the in-service education sessions. As Sita said:

> Sometimes the boards or the parents are meeting the costs and they are becoming too strenuous for them actually, which is something which can be alleviated by the government assisting to post more teachers whom the government is able to meet their salary and therefore comfortably the parents can meet their daily living expenses.

Sita, however, was dissatisfied because his expectation of having the project spreading to all schools and have all teachers in-serviced at a go did not materialize. He said:

> I expected actually the program to spread to all schools, at a go, but unfortunately it hasn't. Some schools are very far. Also I expected that all teachers would turn out at a go, all the science teachers, so that we can have at a go "train" them at once. So that once we

> then, at the end of it, after five years, we would have expected to have the results improved or evaluated after the five-year program.

As pioneers of the SMASSE in-service education project, the district educators expected to be involved in the education of teachers in other districts when the project went national. To their surprise, there was nothing that came their way to recognize their contributions to the SMASSE project implementation. Saba said:

> Now that SMASSE is going national, there are many districts which are getting involved in the program. It would also be okay, if these district "trainers" will also be used to "train" the new districts so that at least they become part and parcel of SMASSE, they can be used anywhere in the Republic.

However, as Sita expounded on how they would have been involved more in the project activities, he felt that the SMASSE Project had abandoned them after the piloting duration was over. There were no promotions for them nor were there plans to involve them in the in-service education of teachers in the other districts when the project went national. Sita said:

> Well this one is a very touchy area because we are the pioneers who started "training" at the national level. We were "trained" and we would have expected that any promotions now coming henceforth, you would be picked. Any of us in our group, the first pioneer group we would be picked and maybe take up the other challenge of "training" others. And this is where I am talking about fair because some of us have taught, some of the teachers have taught quite for some time. Somebody who "trained" the other day who has finished three years or five years was promoted and I have taught for about twenty-two years and I am in the same grade, which is definitely [a pertinent factor].

On the other hand, Saba argued that there ought to have been better criteria of recruiting the project's national in-service educators. In his view, the extra personnel required in the national office should have recruited from among the district in-service educators. This was not the case in the SMASSE project as the programs expanded. Saba said:

> …there were new recruits to the national "training" office who have not undergone this program. I think as we were in there for the "training" it was the general feeling among "trainers" that if there was any person to be absorbed to the national office, then it should have been from among the "trainers" themselves but I think that was not the case.

The participants were grateful that the teachers' employer was aware of the SMASSE in-service programs. However, they wished that their employer would have had follow-up activities to ensure that the in-service education goals were sustained in the districts and schools. As Saba put it:

> I am grateful that our employer is aware of the SMASSE in-service program. And being everywhere, our Government is aware, the whole Ministry is aware. And I would have liked that they make a serious follow up from the national level, come the district level from the district "trainers" and also including our donors, the ones who are financing the project, so that there is that complete achievement of the goals or the objectives. So that the donors don't mind that we are not doing some work here, maybe that they could be the ones who will see by themselves and maybe enforce what actually are our expectations.

In places with national curricula, collaborative efforts in in-service education programs were likely to bear more fruit than when individual teachers, schools, or districts are involved. On the provision and level of availability of resources to teach chemistry in schools, and the assistance brought about by development partners, Saba said:

> We accept that it's the responsibility of our government to provide facilities, teachers and all materials for schools, but then we also know that we are a developing country and sometimes we are limited with resources for the government to be able to provide all these facilities in schools. So, that is why we are very grateful to the Japanese Government for a memorandum of understanding with the Kenyan Government, at least to upgrade or to strengthen the teaching of mathematics and science in secondary schools. So, the issue of donors here is really that they have come very handy, they are willing to assist in areas of provision of facilities and this can be extended to most schools in Kenya, I think then they will have been true and good partners in cooperation for the common good of the Kenyan citizens.

Sita was of the opinion that those who were assisting schools to improve on the teaching approaches and enhance student achievement scores should visit the rural schools. In the schools they were likely to have a true picture of the level of provision of facilities for teaching the sciences. Sita said:

> Well as a citizen, I feel obliged to talk about donors because they are the ones that started the program, who are assisting us and they have played quite a big role. And maybe it

> would be very good, that's my feeling, if they came a cross where we are in our district level, take sometime or even the cluster level or even the schools, they take notes, and they see the problems we are undergoing. Like some of the schools which are not very developed- the science labs are not well equipped, how far they are, they are inside, they communicate with the inspectors there, but the teachers are able to succumb to that and assist in bringing up this. A teacher traveled very far away to collect some conventional apparatus from a fairly developed school, going by foot and this was about eight kilometers and going back the same. I think if our donors would see that and assist maybe this idea of promoting what have you in their proposal, their word would be very strong to our government because as much as we expect our government to be aware of that.

From Sita's argument, it was evident that some schools were far from the district in-service education resource center. Because of poor infrastructure in the rural schools, teachers covered long distances to reach the center and borrow the required items. In his view, more efforts were required to assist these schools by ensuring that there was adequate provision of facilities in such schools. On how the project can involve the rural school teachers in the in-service programs to promote effective teaching of chemistry in their schools, Sita said:

> We are actually limited in resources in that the conventional apparatus we use in our labs are not very expensive if we should buy them actually from the market, but in SMASSE side the in-service program plays a role. So far we are using candles to get results. So in actual sense, if we actually went to the market to buy the resources, we also need capital. We don't have the capital because that is why I was talking in the first instance that if we can get our donor assisting us practically, in fact they will pick more of these teachers from the, who are totally inside there (referring to those in schools in remote areas) take them for further "training", exposure is very important, where they have conventional apparatus, I think we will have this SMASSE spreading like a bonfire. And it will make a lot of difference. So, that is why I was talking about these resources and materially and even financially.

Teachers in the interior schools needed exposure to the new developments in chemical education to enhance teaching and learning in chemistry. They also required finances to buy the locally available materials to improvise apparatus for their chemistry practical sessions. Although locally available materials were inexpensive, many of the rural schools did not have the finances to do so. One way of ensuring that teachers improved teaching skills remained relevant in a sustained in-service education to enhance student achievements, was to provide the required facilities in chemistry teaching. This was one area that the in-service education providers needed to address urgently in the rural schools.

The SMASSE in-service program aspects that were most significant. The student-centered activities, experiments and improvisation (ASEI) movement and the plan-do-see-improve (PDSI) approaches in lesson planning and teaching chemistry were found by the participants to be the most significant aspects of the in-service teacher education programs. As Saba put it:

> …we came across new terminologies, things like an ASEI lesson plan, PDSI approach to teaching. It is my opinion that this was a very significant aspect of the program. When we talk about an ASEI lesson plan, ASEI stands for Activity, Student-centered, Experimentation and Improvisation. So, in this case we focus on the student.

The ASEI movement in lesson planning and the PDSI approach in teaching secondary school chemistry were important aspects because prior to the in-service programs, teaching used to be more teacher-centered. The teacher-centered approaches were not very effective in assisting the students to attain higher achievement scores in the national examinations. There was need to involve the students on chemistry learning activities especially by doing experimental work on their own. Saba, further, commented:

> Most of the teaching in Kenya was so much teacher- centered but then we noted that students absorb more, learn more if they are given more activities or if they are involved in things like experiments. During experiments, experiments which are possible and can be done for students, the students are made to do them by themselves.

The new approaches to lesson plan preparation and implementation ensured that a teacher had student activities. As Saba put it:

> In the planning for the lesson, we are using the acronym PDSI. PDSI here stands for Plan, Do, See and Improve. So, as you know you are going to teach a particular lesson you **plan** what you are going to teach. You plan by looking at what you would be required for proper implementation of that particular lesson. So, you have very old materials required for that lesson at the planning level. Then it reaches a stage where you have to **do**. So **Do**

> here standing for doing, this is the particular time when you are actually teaching. So, as you teach the lesson, you are executing what you had actually planned.

Prior plans on lesson evaluation were great to the participants. From the focus group discussion, it was evident that through appropriate lesson evaluations, teachers were able to improve on their subsequent chemistry lessons. As Saba continued stated:

> Then, after you have taught you need to **see**, did the lesson go as per my planning? If it went as per my planning, that is fine. If it didn't go as per the plan, then why did it not go as by the plan? So, in a way I am evaluating the lesson under the signal of the seeing, evaluating if things went as per my arrangement. If they didn't go, then I go to another stage, which is the **I,** whereby **Improve**. At this stage, I will have learned, I will have executed the lesson, I will have evaluated the lesson and then I will be able to plan for the next lesson in a better way and therefore my approach in the next lesson will be having a lot of improvements. And this area I feel I really benefited and it was the most significant area in my in-service teacher education program.

Sita was in agreement with Saba's assertions on the new approaches to planning and implementing chemistry lessons following the in-service education programs. The ASEI movement and the PDSI approach had a great impact on the teaching of secondary school chemistry. Sita said:

> My colleague talked about ASEI lesson plans and PDSI approach. These are correlated areas which are very important. In fact they are a correlated part in the SMASSE which are very important because they are self evaluation and you just see, you end up finding some positives and they are indicators, they can easily indicate whether you are going backward or forward. They were quite very touchy areas.

Improvisation of teaching materials using locally available materials was another aspect the district in-service educators found was of significance to them from the SMASSE project. As Sita put it:

> And another aspect, the most important area in this ASEI is improvisation; the word improvisation is a very simple word in itself, but when it came to its actual use using the local cans, using local materials to carry out experiments in chemistry. That is wonderful. So, those aspects really touched me and I think it made me feel that chemistry is getting some edge.

On the issue of improvisation, Saba felt that they were able to collect materials to improvise in the teaching of chemistry. The advance collection of waste organic materials for teaching organic chemistry kept the school environments clean. Saba said:

> …the area of improvisation we are encouraging most of the time that we use local materials. You find that when you are moving around there is a lot of waste in the name of plastic materials, metal cans and all that, but we have come to realize that these materials are very important. So, most of the time when we see these materials lying there, we pick them, we store them somewhere and at some stage we are able to use them to improvise a particular equipment or something that can be used for experimental purposes. Other than this being used for experimental purposes, I think it has also helped to keep our environment very clean by our collecting these materials, which are just thrown away anyhow.

The district in-service educators were exposed to actual teaching and observations by colleagues during their national in-service education programs. Sita said:

> I was also moved by some aspects. One of them was the actual class teaching situation, where we had to go to selected schools. Those ones who were "training" at the national level and us teachers of chemistry, we had to go to selected schools, carry out the actual teaching while the others observing. That one gave me a very benefiting experience because these are professionals handling a lesson and there is evaluation going on by the colleagues. That one I think was quite good.

The district in-service educators were pleased to have the SMASSE in-service education taking place in their district. Sita, further, commented:

> Another aspect is "training" of science at the district level, I becoming a district "trainer" in science so that at least you expect everybody including the local community that your son has got so much like that because it is somebody you are "training" in chemistry. At least that image now we are getting even our students, we have pupils from primary are getting some action, that there is some science at secondary school level. So, the aspect of SMASSE actually spreading up to the district level and touched every lab in the centers.

According to participants, the in-service education was portraying a positive image about the teaching and learning of science within the local community.

The SMASSE in-service program aspects that were not significant. Although the participants found SMASSE project of quite value in the in-service program, they however found the cluster in-service education not to play an important role in the project implementation. The clusters were found to be uneconomical to run. On the cluster in-service education, Saba said:

> I found it was supposed to "train" some teachers at the district level, those ones who were the ones to take over as per our initial program, take over and "train" others at the cluster, small units. However, we did not find it very original so that one I think I did not find it very important actually because we had to scrap it off actually…Because there are some technical [issues] like materials for example, acquisition of materials, at least we found it very cumbersome and we were even now making it more costly. And that is why we had to establish clusters and our district is still very large. That is what actually made us see them not as significant at all in that aspect of SMASSE "training".

The district educators felt that in-service all teachers at one center in the district ensured originality in terms of what they were exposed to during the in-service education. By the time teachers were in-serviced at the cluster level, there was likely to be a distortion of knowledge imparted through the cascade system. As Saba put it:

> We found it if we "trained" from original since we have "trained" at the national level, we come to the district level. So, as the district "trainers", we had to take up the aspect of "training" and that would bring some originality so that there is no distortion of the "training" issues.

The district was large while the cluster schools were far from each other. The district in-service education kitty had insufficient funds to run the cluster centers. It was economical in the participants' opinion to in-service teachers from a more central place: The District In-service Resource Center.

Another aspect the district in-service educators did not find significant in their program were the national in-service education monitoring and evaluations. The stakeholders in the in-service education are found in the districts and it was at the districts that the SMASSE project was expected to be felt. Against this context, the district in-service educators did not find the national monitoring evaluations having any impact on them. In the comparison of the national and district monitoring and evaluations by the project, Sita said:

> …monitoring and evaluation at the district level, I think it was important. But at the national level, I didn't find it very important. At the district level, I found it very important because that is where the actual activity is found, where the whole in-service is taking place. There were the students, there were the actual "trainers", there were the teachers who were "training", and there were the stakeholders now fully involved. I think that is why the evaluation was very important but at the national level I found it not very important.

Saba felt that the national monitoring evaluation team needed to visit the interior schools in the districts to have the actual picture of the teaching and learning situations following the in-service programs. Teachers were faced with many constraints when attending the in-service education courses. Visiting the most interior rural schools and the in-service education centers was likely to provide a true picture of what was happening on the ground. As Saba put it:

> …in most cases the monitoring and evaluation teams visited the "training" centers probably one day or two to assess and have a picture of what was going on. I think it's my feeling that the monitoring and evaluation teams need more time at the "training" centers to know exactly what actually goes on in the "training" centers. So my appeal is that for a good report to be written about the "training" there is need for that team to be at the "training" center for a reasonable time so that the reports can cover various areas and be rather accurate.

It appeared that the national SMASSE monitoring and evaluation team's work had not done a great job. The evaluators needed to take sometime to visit the in-service education centers when teachers were being in-serviced. The evaluators were expected by the district in-service educators to stay in the centers for the whole duration of the in-service courses. Sita commented:

> I would like to comment on what my colleague has said. Actually, what you have said is true about our evaluation team. Taking at least sometime at the center where the actual "training" takes place, solves out the problems, makes the actual situation to be real rather than abstract, because you see the problem there, see what we need, in the number of participants and even sometimes you can take time with the results from our schools. You bring them there and they can be evaluated. Otherwise, I concur with my colleague about the team, the team should have some time, at least.

Full time participation and observations by the monitoring and evaluation personnel would have improved the in-service education as their recommendations would have been based on the actual situations at the districts.

Changes in lesson planning and teaching following the in-service program. Among the changes that the participants had made was the incorporation of the ASEI movement in their lesson planning and the PDSI approach in their chemistry unit lesson implementation. Saba said, "…from the SMASSE program we have learned about the PDSI approach to teaching and the ASEI lesson plans. We are currently using this approach and the ASEI lesson plan in our teaching. So the approach has improved." Previously, the participants were not evaluating their lessons with an aim of improving on the implementation of the subsequent lessons. Following the in-service courses, the teachers had changed their teaching to incorporate prior planning on lesson evaluations. Saba commented:

> For one previously we never used to assess our lesson with intention of improving the next lesson but now we do that. In our lessons now we have to plan for it look for the materials required and not that particular moment during the lesson that we are running up and down to arrange this and that but we put them ready in advance.

The district in-service educators had made changes on the learning activities. The lesson activities were learner-centered. Sita had a teaching metaphor on how to involve students in chemistry teaching. He believed that as students participated in various learning activities, the teachers should "let the child do as the teacher sees." This was a great change from the teachers' demonstration classes they mostly used to have whenever they conducted experiments in class. As Sita said:

> …let me have this one as "let the child do", that should be heading, the PDSI approach is actually sort of "let the child do as the teacher sees" unlike previous times when we were carrying out experiments by ourselves demonstrating. This time we have the child or the pupil involved.

The student-centered chemistry lessons were teacher-friendly. The teachers were able to teach any part of the curriculum as they improvised the teaching and learning materials. Sita said:

> And our lessons are a bit friendly because sometimes teachers can fear going to handle like a double lesson, depending on the nature of the topic and the available apparatus or equipment. But the inclusion of this SMASSE, the PDSI approach and with the ASEI lesson plan always ensures the lesson is very friendly, the student is there [to be taught and learn], they can use the local materials, [which] we don't go to purchase.

The lessons were teacher friendly because of the student-centered activities. The students fully participated in the learning activities while the teacher played a role of a supervisor during the chemistry sessions. As Sita expounded on how the changes they made in their chemistry lessons were teacher friendly, he noted:

> Being friendly in the sense that there is this ASEI activity for the student, an activity which the student must be involved in the experiment, more experiments, at least every student, you divide them in small units, they are able to do those experiments and from there we improvise. In fact in the improvisation they should be involved. So, in most of the cases it is the student who is just doing the experiment, here you are to supervise and therefore you don't strain", you don't talk a lot, they do a lot and give you the [measurement] you talked of and you find you are comfortably moving with the lesson.

The teacher's role as a supervisor during student-centered activities meant that students were left to perform their inquiry-based learning on their own. The teacher was there to ensure that the students participated fully in the learning activities and was there for those who needed assistance. As Sita said:

> In the PDSI we have the planning, the doing, and the see. These are involved in the **planning** from the aspect of the teacher, the **doing** is from the aspect of students involved, and the teacher is there as supervisor. But then the **seeing,** the students are involved to see what they are doing, and then from there you improve.

In addition to what Sita thought was the teacher's role during the student-centered learning activities, Saba felt that the teacher had to play the role of an evaluator. The teacher had to evaluate him/herself or use students' feedback to evaluate the success of the lesson implemented.

The evaluations helped the teacher to improve on subsequent chemistry lessons. On the PDSI approach to chemistry teaching, Saba said:

> I think the **seeing** aspect is also the evaluation. It brings the evaluation aspect, whereby you are able to evaluate your students, whether the students have understood and even as the teacher under the planning and doing section, the teacher can equally evaluate himself whether did the things go as per the plan during the process of implementation and they help us to improve later in our next lessons.

On the other hand, Sita's assertion on the use of locally available materials in preparing teaching and learning aids was supported by Saba who commented:

> Alongside that in the ASEI lesson plan the area of improvisation is really emphasized and we are now using local materials in a situation where we don't have the equipment or facility required. And I think in one way we are helping our students much better. So our approach to teaching, the teaching of chemistry has changed for the better.

The use of locally available materials in the teaching of chemistry units had eased a financial burden on schools which had to buy conventional materials for teachers and students' use. The changes made in the planning and teaching of chemistry unit lessons had somehow lead to a healthy relationship between the heads of institutions and their chemistry teachers. As Sita put it:

> The head of the institution is very comfortable because sometimes it makes even the head of the institution frustrate the science teacher in handling of the lesson during the teaching process, during the acquisition of the materials. But with this improvisation, the ASEI lesson plan, it helps bring out some of those problems. It caters for that and therefore the teacher is able to handle the lesson very nicely without any problem and at least not financially strenuous because you are in most of it is improvisation.

The changes teachers made in their planning and teaching of chemistry units following the in-service programs were likely to benefit the interior rural schools which were poorly equipped with resources for science. Sita, further, said:

> And some of our schools especially which are in the interior, which are not so developed, we have a lot of these materials, all kinds of plastics are there to use. So, you find a topic like organic chemistry to handle it there is so comfortable. So, I think you find the approach so good because of this SMASSE program.

From the participants' discussions, it was evident that the changes they made in planning and implementing their chemistry unit lessons were friendly to the teachers and assisted students to learn better in many rural schools. The new format of lesson planning and implementation had reduced the schools' financial obligations in providing the conventional materials for science teaching thus making the school heads and chemistry teachers to have a cordial relationship.

Change in areas not covered in the SMASSE in-service program. The district in-service educators were able to make changes in other topic areas that were not covered in their in-service education courses. The changes they made were dictated by the demands of the chemistry topic being taught. As Sita put it:

> Well, there are few things which you are sometimes forced to change and you change according to the kind of topic you are actually handling. Because like for example, the lesson plan, you can change it depending on what you have, the kind of materials you have at hand, that way can make you change. But there are some key factors during the rest of the planning which you are forced to change.

According to the participants, the project gave them a leeway to make any changes on the ASEI lesson plans and the PDSI approach in their teaching. The freedom of making the changes during the in-service education sessions ensured the participants' ownership of the changes made in their chemistry unit lesson plans and implementation. Saba observed that:

> …actually as much as we learned this PDSI approach to teaching and the ASEI lesson plan, we were given opportunity to make any amendments to it and after a lot of surveying, we agreed on the format of the ASEI lesson plan and we all appreciated the PDSI approach to teaching. So, in my feeling the approach was adequate.

The district in-service educators came up with a lesson plan format which had the teaching/learning activities and lesson notes columns. On the format of lesson plans, Saba added:

> The formatting of the ASEI lesson plan, the ASEI lesson plan is in such a way that the activities to be done at the various areas, at introduction, maybe the development of the lesson and all that, they are accompanied with the lesson notes. So, you find that the ASEI lesson plan has got activities and notes corresponding to the various activities and expectations. So, that is really what I may say about ASEI lesson plan.

The lesson notes serve as a guide to the teacher on the key points of the topic concepts students should take note of. On the inclusion of the lesson notes in the new lesson plan format, Saba said:

> These are notes for the students but then the teacher has put down as a guide and will be able to give a guideline, they help the teacher to guide students to make notes by highlighting the key points. The key points are inscribed in the lesson notes, which are contained in the ASEI lesson plan.

The involvement of the in-service participants in designing the format of the ASEI lesson plans and how to implement the PDSI approach in teaching chemistry unit lessons were some of the important changes made in the project.

Planning and implementing chemistry unit lessons following the in-service program. The participants gave their views on how they planned and implemented their chemistry unit lessons involving the periodic table, "mole concept", electrochemistry, organic chemistry, and other topic areas they taught following the SMASSE project in-service education programs. The following are the participants' thoughts about their secondary school chemistry teaching.

Planning and implementing lessons on the periodic table. The participants had many approaches as to how they taught the periodic table. They ensured that the students understood the atomic structure, followed by the electronic configuration of various atoms before they embarked on the periodic table. Sita said:

> The periodic table actually, the approaches are many. But the real approach, which I would use here, is the students should be familiar with the structure of the atom, such that the electrons in an atom and the electronic configuration should follow.

Once the students have mastered how to write the electronic configurations of atoms, they are then introduced to grouping the atoms together based on the number of electrons they have in the outermost energy level or the number of energy levels they have being occupied by electrons. The students are then given the criteria for placing elements in the various groups or periods in the periodic table. As Sita put it:

> …they should be able to accept that the uttermost energy levels, the electrons in the outermost energy level are the ones, which are displaced. They are the ones, which can classify a given atom or a given element in a group and the fact that the number of the energy levels is the same with the period to which that element belongs.

Nane concurred with Sita that the teaching of the periodic table should start with the atomic structure. The students should be assisted to know how to write the electronic structures as a pre-requisite for understanding how the periodic table was developed. As Nane put it:

> …what [you need to start with] is actually the structure of the atom. The electronic configuration, make use of the other interactions in putting the elements in groups and also the use of the number of energy levels in giving the elements their periods. So at least in trying to talk about this periodic table, the students must be able to have that knowledge of how to write the electronic configuration and use the electronic configuration to put an element in a group and in a period.

The students are involved in various activities by drawing of charts on the periodic table. Saba said:

> **...**about the periodic table, the teaching learning activities involved here, for example, I involve the students using charts to try and draw the periodical table and group the elements of some similar characteristics probably the a number of electrons uttermost energy level and all that. So those are the activities students are normally involved in during the process of teaching. The resources here are things like the charts, the pencils and all that.

The use of charts in teaching the periodic table was supported by Nane who said that "actually use of charts is recommended and of course after the lesson you need to also to give some questions on the periodic table to get them to be able to even draw their own periodic table using the atomic numbers", especially for the first twenty elements in the periodic table. The students need to know more about the atomic numbers and masses. This helps students to have deeper understanding of how the elements are arranged across a periodic table or down a given group.

The use of student activities when teaching the periodic table was supported by Sita who said:

> …then, we will have a few sessions to prepare, students should be able to prepare a small chart with the first twenty elements and should be able to write their electronic configurations, properties given atomic number. The students should be informed what actual atomic number is so that they [know] what the relative atomic mass is. So that in relation to what really happens so that they know why the elements are arranged across a given period and also as within the same group why they are like that.

The participants argued that the students can be made to appreciate the trends in the reactivity series based on elements affinity for oxygen or reactions of elements with acids or water. Sita said:

> And they (students) should be able to also appreciate the fact that these elements, the reactivity series from the initial approach on the affinity for oxygen, all reactions, I should say, the reaction of metals with acids, with water. That fact alone would give them at least some close approach to the accepting about the arrangement of the elements within a given group.

On the other hand, Nane used letters that did not correspond to the elements' chemical symbols when giving students activities to perform on the periodic table. The use of letters other than the real chemical symbols of the elements ensured that the students understood the concepts underlying the periodic table without cramming the properties of the elements based on their symbols. Nane said, "the activities, of course lecturing, the students should be given a few atoms even using letters, which don't respond to the correct symbols of those elements to write their electronic configuration once given the atomic number."**.**

On lesson evaluation to gauge the students' understanding of the periodic table concepts, Sita felt that the students can be asked to write the electronic configurations of atoms, tell the reactions of elements and the compounds formed during such reactions. From given information, the students should also be able to predict the groups or periods of various elements. As Sita put it:

> And on the lesson evaluation, let the students find the electronic configurations, be able to tell the reactions, the various compounds formed when certain elements combine, be able to predict which group an element belongs to from the electronic configuration. I think this will give the students some good approach on this topic.

Saba commented on the importance of doing lesson assessment as the lesson progressed. He said:

> And the evaluation is normal. At the end of it all the students, are they able to, are they able to draw the charts representing the periodic table? If not, then we evaluate the lesson accordingly and then maybe help the students to know what was accepted of them.

From the participants discussions, it was evident that they taught the periodic table by considering student activities on the atomic structure, electronic configurations, reactivity of elements (involving oxygen, acids and water), and drawing charts on the periodic table for the first twenty elements. The participants discussed the periodic table using letters to represent elements, which were not their true chemical symbols. Lesson evaluations were also conducted to assess their students' grasp of the concepts about the periodic table. The lesson evaluations ensured that the students were achieving the lesson objectives in relation the teachers' expectations.

Planning and implementing lessons on the "mole concept". The participants thought that the "mole concept" was a wide topic that needed to be approached carefully to benefit the students. As a number, the "mole' should be approached from the counting concept. The counting should be based on students' familiar items. As Sita said:

> …the "mole concept" is a bit also wide…because mole, the idea of moles, we are talking of a number and therefore we might begin with counting. And what are you going to count? We are going to count atoms, electrons, ions and molecules. And we can explain it further. We can count even beans, the local things which the students are familiar with

and before you approach the actual lab because most of our students, those who are below average will get the concept very well if you bring it home to the familiar things which can be counted.

The idea of counting was extended to proportionality of other units of measurement such as meters and mass units such as grams. Sita stated, “through that counting you can easily now bring the idea like say we have one kilometer is a thousand meters and therefore how about how many kilometers do we have in 300 meters?” Students are then made to convert given masses into moles, as a unit of measurement equal to the Avogadro’s number ($6.0x10^{23}$) of particles. With many activities for students, the “mole” becomes an interesting topic. The students are exposed to the “mole” of particles such as electrons, atoms, molecules, and ions. Sita said:

> Then we are trying to bring the idea of converting grams to moles. And therefore the Avogadro's number coming in because, that is a number, 6x10 to the power of 23. And you relate it to one kilometer is a thousand meters and one mole is therefore this number of particles. So the “mole concept” is a very interesting topic and you can have so many activities for the students to actually take part.

Saba used analogies that involved the students familiar counting units such as dozen and gross before defining a “mole” as a unit of measurement equal to $6.0x10^{23}$ of particles . He said:

> …I also would like to add that the same analogies can be used, like for instance, dozens standing for 12 items, a gross standing for 144 items. And we can say a “mole” also stands for a particular number of particles, which has got the number of particles 6.0 x 10 to the power of 23. The existence of particles, for the student to know that which particles we are talking about here, the particles can be electrons they can be ions, the molecules.

According to Nane, the “mole” should be introduced without the word “concept”. When the two words are used together they confuse students with an impression that the topic was difficult to study. As Nane put it:

> …I could add that the “mole concept” being a very wide topic; now give to students with problems especially the idea of the “mole concept”. So I don’t know whether we could change this one and have it as the “mole” that we don’t include the ‘concept’ so that

> when we talk of the "mole" to look at it as a unit of measurement. And when they realize that it is a unit of measurement of course now they will relate it to what they use as centimeters, meters, kilometers and other things.

Another way that the "mole concept" was introduced was through student activities to compare the capacity of a set of two apparatus, that students were familiar with, such as beakers (of different sizes) and items such as sand. The students were to find how many small beakers of sand were to fill the bigger beakers. Nane said:

> Then of course, the introduction sometimes you can introduce it using beakers, for example of different sizes, you fill the small beaker with sand for example and try to know how many of these beakers containing sand will go to the bigger beaker. So that at least they use a small beaker as a reference but the smaller unit that we could have.

The concept of having electrons in atoms is sometimes abstract to many students. To start dealing with a "mole" of electrons became more abstract to this group of students. The existence of electrons was demonstrated using locally available materials such as two inflated balloons. As Saba put it:

> As far as electrons are concerned, two inflated balloons can be rubbed against hair and later it is found that that these balloons start repelling one another implying that the surfaces contain now a similar kind of particles and that is why they are able to repel. And this one helps students to know that electrons actually exist.

The existence of particles in solutions was demonstrated using colored substances such as potassium permanganate. The dilution effect on dissolved potassium permanganate assisted students to understand that ions can also be counted. According to Sita, "dissolving of colored substances such as potassium permanganate, whereby the color is able to spread to various parts of the container, will be able to show the students that matter is actually continuous."

From a previously observed lesson on dilution experiment, Sita was asked to comment on why his approach in teaching the "mole concept" was different from the rest of his colleagues.

The way one planned and implemented a “mole concept” lesson depended on the type of students one had and the type of counting the students had to do. In his lengthy response he said:

> My approach is basically counting because here is a case where they are trying a dilution experiment. Diluting potassium permanganate, they are trying to count. Probably with more dilution the last color or color disappears, and then from there we do an estimate. It is a form of counting now here we are counting the ions. There are cases where we are counting the actual particles like counting atoms, counting the beans, you are not counting ions, we can even put on the word atom, and we are counting the atoms. Actually what I was trying to bring about was that as much as we know of atoms, I was bringing the ions issue. So that the idea that matter consists of particles, smaller particles, is passed to students very well that as much as there is a crystal, there are smaller particles and can we count smaller particles? Yes, through dilution. That is how I may do it. There are approaches, various approaches, my friends are right, that is another way, their approach is correct, and it can bring the sense. In fact you weigh the type of students that you have. Our students, I think there are some who are above average, you can have a class, which is slightly just average, there your approach must use is to "come down" so that the message is clear. There are cases where you have a class, which is slightly above average. That class, you find even the way they ask the questions, you “trained” as a teacher, it is a question, and as a “trained” SMASSE teacher, you would be able to weigh. And then tackle the question, which will improve the method that is why we were saying about the ASEI, the PDSI, Plan -Do -See and Improve.

Another way that teachers exposed students to movement of ions was based on simple experiments on electrolysis processes. These simple experiments also helped the students to understand that the ions too can be counted like any other particles. Saba said:

> We have the, trying to expose students to ions by carrying out some simple electrolysis, trying to exposes students to movement of the ions itself as we are exposing students to know that they are ions and therefore they can be counted as well.

Calculations on the “mole concept” were found useful in assisting the students to understand the ideas on the topic. The participants planned for student activities on the “mole concept” calculations. As the students solved the “mole” related problems, they were able to appreciate the applicability of the topic in their everyday lives. The calculations were followed by discussions under the guidance of the teacher. The teacher did continuous lesson evaluations during these teaching and learning activities. As Saba said:

> On the “mole concept”, so far it happens to have a lot of calculations in the name of solving problems, so one way, is to involve students in the calculations and then discussing all those after the calculations. In line with the ASEI movement, in the “mole concept”, students can really be involved in calculations and such kinds of activities. But then, at the end of such a lesson evaluation can be done on areas, which students maybe found difficult or something like that. So that they are able to exchange views with the guidance of the teacher and [with this] for the subsequent lessons the teacher is able to make amendments as a way of trying to improve on the lesson.

Nane felt that students have to be given simple “mole concept” problems to solve before they were introduced to more complicated problems. He said:

> So in that case with all the calculations, they will always have problems. And this one of course, they have problems because they have a problem in the imagining. So these boys or girls who have problems in calculations, you need to give them simple questions on calculations so that once they do them they could be induced to do more of these problems.

The students were found to be having problems in solving calculations relating to the molar or formula masses. The teacher had to tell the students how the molar or formula masses were obtained. As Nane put it:

> Then, the problem usually I get is that of relating the formula mass or the molar mass to the calculations, how is it that, like now, when you talk of let’s say sodium hydroxide, it’s a molar mass is 40 grams. We talk of it as a molar mass but in essence it is not easy for one to relate how this mass is obtained. So maybe you have to tell them that these are arbitrary numbers given to these atoms so that when they are added together you will get the mass, like now the atomic mass is in grams, etc. So that they use those masses, and given like now, these 40 grams is the mass of one mole of sodium hydroxide.

Sita concurred with Nane that students asked questions about the formula and molecular masses. The students were asked to identify the number of atoms found in a given chemical formula. According to Sita, the students are assisted to solve the “mole concept” related problems when they are reminded about the formula or molecular masses and how to determine them from given information. By so doing, the students were able to follow and solve the "mole concept" problems with ease.

Planning and implementing lessons on electrochemistry. The participants found the teaching of the electrochemistry unit very interesting once the periodic table had been thoroughly covered. Students' thorough understanding of the atomic structure and the chemical reactions involving loss or gain of electrons by the reacting species was a pre-requisite for the electrochemistry unit. Sita said:

> …electrochemistry is an interesting topic because once you have done the periodic table that we talked about before [and] we have done about the electronic structure. Students know what an electron is, they know which electrons an atom can lose and which it can gain and therefore the introduction of the ion, I think does not become so difficult because here you will have a lot of materials around to use.

The participants used locally available materials to conduct activities on the electrochemistry concepts. The electrodes used to demonstrate the electrochemistry concepts were the carbon rods from dry cells (flash light batteries), while the electrolytes were the lemons gotten from the local community. The involvement of students in learning electrochemistry based on their practical experiences motivated and made them curious to want to explore more on this topic area. Sita noted:

> You have the torch cells, to remove and get the carbon rods to act as electrodes, for terminals, positive and negative terminals, you have the lemons which they chew, the students use [and] they have them in their local markets. We go ahead, even our toilets, pit latrines when connected with circuits, they light. So some of the students would be interested to know how this works and this would motivate them and therefore the topic would come out very clearly.

Other locally available materials that the participants used to demonstrate the movement of ions in the electrochemistry processes were the red cabbage solution and carbon electrodes from dry cells. In a complete circuit, the colors in the red cabbage solution separated because of the movement of positive and negative ions to the cathode and anode respectively. This demonstration was more effective in explaining the flow of current unlike when the lighting of a bulb in a circuit showed that there was conductivity taking place. As Saba put it:

> …another teaching learning activity that can be incorporated is, for instance, when explaining about movement of ions, we can squeeze red cabbage so that we are able to get the cabbage in solution form. And then connect a positive electrode and a negative electrode so that when the circuit is complete we are able to see movement of ions in terms of separation of colors, which makes it very interesting to the students who watch. When it comes to the areas like conductivity instead of the usual way whereby we use a bulb, when the bulb lights, then there is conductivity.

Saba, further, explained how other teaching aids can be improvised to make the abstract concepts in electrochemistry simple for the students to understand and enjoy learning electrochemistry. In many situations, the use of bulbs lighting to show that a given solution was an electrolyte could not work for weak electrolytes. The participants used a musical card, connected wires and made a complete circuit with the solution being tested for conductivity. The musical card played even for very weak electrolytes. Saba said, "…we can use a musical card whereby the music will start playing when the circuit is complete and this is quite interesting to the students."

Following electrochemistry concepts using locally available materials was not a problem to students who already had prior knowledge about electrons from the periodic table unit. Supporting Saba on use of locally available materials to teach electrochemistry unit, Nane said:

> …with electrochemistry, somehow we have enough resources, when you plan you can always make use of these locally available resources. And in implementing it, is very easy now at this point when it is actually taught. The students have already the knowledge of electrons, what are the electrons, what are the ions and therefore there isn't actually much you would have.

Nane suggested other approaches that enhanced students learning of electrochemistry concepts. He believed that prior to the start of the electrochemistry unit, students should be thoroughly prepared on the oxidation and reduction processes. The students' understanding of redox reactions, were important in learning the electrochemistry concepts. They needed to have thorough understanding of oxidation numbers, oxidizing and reducing agents. As Nane put it:

> …what…I found out is that these terms where they are applied, oxidation and reduction during the electrochemistry. When maybe an ion gains an atom what is it? When maybe an atom loses electrons, what happens? This is oxidation and reduction, of course. So, at least those terms are a bit confusing to the students. At least, it needs to be well explained so that the students get to know. Then, they have the use of oxidation numbers in tracing the oxidized and reducing agents…it should also be emphasized so that students come to know about this reduction and oxidation.

However, the participants found students having problems doing calculations on electrochemistry concepts. According to Nane, the students' problems in electrochemistry calculations were because of their poor background in mathematics. The participants assisted their students in electrochemistry calculations by having them do simple calculations first. Then, as the students improved on their calculation skills, more difficult problems were then introduced. Nane had noted:

> …otherwise where I know we have a problem with the paradigms when it comes to doing calculations. Still I would say the students usually get problems in calculations because of their poor [background] in math, so at least again we need to make use of simplified examples so that from there we can improve their skills in calculations.

From the participants' discussions, it was evident that they used locally available materials to illustrate electrochemistry concepts. The use of local examples and students participation in learning activities made electrochemistry lessons interesting and motivating. The students with calculations problems were given simplified examples before they embarked on advanced calculations on electrochemistry problems.

Planning and implementing lessons on organic chemistry. Organic chemistry was another interesting topic to teach. The participants introduced the topic on organic chemistry using students' familiar items and practical experiences with organic materials. As Sita put it:

> …organic chemistry, which is actually I think, is a very interesting topic. As a topic, first life, organic chemistry is life. So the first thing the students be able to come in if they identify the things that they need in their life, themselves, their bodies, we talk of carbon and should be able to tell the students that actually organic chemistry is carbon chemistry. Throw them a few questions on carbon, they are familiar with carbon so the word organic does not scare them so much. And the goodness or the advantage in this topic is that it has got so many materials for use.

In organic chemistry unit lesson planning and implementation, Sita observed that generally "there were a lot of resources, which will not be an expense to a school, even in a young school, which does not have enough materials." When teaching about polymers, the participants had plastic containers and polythene papers available within the school environments. The teachers used locally available kerosene (paraffin) and turpentine as examples of organic liquids. Sita said:

> …You talk about polymers, you have plastics around, you have the polythene papers from shops, and we have plastic cans when we buy cooking fats from the shops. We have a lot, they have the paraffin when we come to organic liquids, and there are the alkenes so that they are talking about double bonded compounds or unsaturated organic compounds, we have the paraffin, and we have the turpentine.

Students were made to heat the polymers collected from the waste materials and classified them through heating or the flames they produced when burning. Sita added, "some of these materials when we are talking about, when talking about saturation, some of those polymers, it would be very easy to classify them through the heating or the kind of flame they produced." The students were further involved in discussions based on their practical experiences on the polymers used in cloths such as nylon and polyesters. These discussions made the students to visualize the real applications of organic chemistry in life. As Saba put it:

> Polymers are in big use in the name of plastics and all that. Plastic basins students have seen them in their lives and it is a good idea to let them know that these are actually organic compounds. When you talk about polyesters students are used to that kind of cloths. When we talk about nylon, they are used involving putting on such kind of cloths. So these are topics which have a lot of applications and very real to the students.

According to Sita, students were involved, further, in discussions on biogas "which the students will be very much interested to know why it is organic." Sita felt that there were many student learning activities in organic chemistry, which made its teaching interesting and easy to cover. The students collect the organic materials from their homes/school compound. As Sita put it:

> So some of those, I think organic chemistry teaching is very easy because from the starting to the end. And there are a lot of things which students can be involved in terms of activities. The students themselves can come with those materials from their homes. That is the advantage with it…So this is a very interesting topic to students when it comes to the actual teaching. It is a bit soft; you know it is soft because the materials are many.

Sita's assertions on teaching and learning activities in organic chemistry were supported by Saba who suggested that students collect local materials from which they prepared models of organic compounds. Saba said:

> One other teaching /learning activity students can be engaged in this topic is one where we are talking about structures of certain organic compounds like alkanes, alkenes. For instance, if students collect marbles they can be used to represent the carbon atoms and then appropriate structures can be made so that is one way of improvising in a situation where we do not have models of this particular compound made.

Local brewing processes were discussed in class and then connected with the industrial manufacture of alcohols. The students' understanding of alcohols manufacture and their use were reinforced through visits to local breweries. The teaching of alcohols using local processes made the students' learning real. Saba said:

> On other topics like the alcohols, alkanols for that matter, students have experienced the preparation of alcohol in their homes in the preparation of local brews. The lesson can be built by the teacher asking students, what they know about preparation of alcohol. And

> from there, the teacher will build it up to talk about industrial manufacture of alcohol. It is very appropriate at this stage that students visit even a nearby brewery if there is one to make learning more real to them.

Real life situations in which organic compounds were made use of were found to be of great benefit to the students. The teachers drew the students' attention to as how carboxylic acids were useful in identifying individual people by dogs. Discussions involving real life situations made organic chemistry relevant, interesting and enjoyable. Saba said:

> Other topics like the carboxylic acids, their uses and all that. The idea that the dogs…we learn that dogs use the smell of carboxylic acids to be able to identify a person. So at least we have for instance police dogs, which are able to follow the culprit to wherever the culprit is. So the students see the relevance of some of the things that they are learning.

Nane extended his teaching into more complex but familiar compounds such as proteins in the foods they ate. He commented:

> It's true that organic chemistry is a topic, which is very important to life. And it so happens that actually even before they start talking of these other compounds like ethanol, the alkanes, you know what they use even during their lunch, if they are coming from lunch, you talk of beans. The beans, you know, they have compounds in them, which we have organic compounds like the proteins. Then you have the cereal and it is one of the examples of the organic compounds. So at least in planning and carrying out this topic, the resources are available.

However the students had difficulties in writing the molecular and structural formulae of organic compounds, especially those with longer structures. The teachers made their students to start writing structural formulae of shorter molecules and once they knew how to write them, they were then introduced to longer molecules. As Nane put it:

> …the students have a problem in writing of these formulae, the molecular formula and structure formula of these compounds. I think that is where we have a major problem. When they see maybe you are writing a long structure and you call it a formula of a compound that is what made them not to pay attention. But at least it can be simplified by using examples with, maybe which have a shorter structure formula and from there they build up the ability in writing the structures and of course learning. But otherwise, I found it as a topic where students enjoy.

Sita agreed with Nane that the students enjoyed learning organic chemistry. Sita used local colored beads to construct the organic compound structures. This approach assisted the students to understand the topic better and the materials used were cheap and easy to use. Sita said:

> This topic seems interesting especially when I am handling structure and bonding when talking about alkenes, alkynes. You get beads problems, see you can buy beads for five shillings, you get a number of them and they have different colors. Then have toothpicks, sharpened on both ends. [You don't need to spend a lot on the sharpened…], they are very cheap, and ten shillings you get a lot of them in a packet. You can connect there and increase their understanding. I think as my colleagues have said the topic is very good. And the teaching of it becomes very cheap because most of the materials are available locally.

Nane suggested that teachers used (ripe and unripe) small round wild fruits to represent carbon and hydrogen atoms when making the organic compound structures. This way organic chemistry was taught without much cost to schools. Nane said:

> Sometimes if you don't want to spend even a penny, you can always use [pebble-like wild fruits]. Put together the ripe ones and the unripe so that you have one of them using carbon, and the other using hydrogen and we use it [that way].

In this context, Sita observed that organic chemistry became "very interesting in fact and the students are familiar with those [pebble-like wild fruits] so it is a matter of just collecting, coming with them from their homes. They connect them very well." It was evident from the discussions that the participants used locally available material, local processes, and student-centered activities to implement the organic chemistry unit.

Implementing other chemistry topic areas. Sita argued that various chemistry unit had different planning and implementation requirements. He observed that some areas of chemistry unit might not need student involvement or use of conventional apparatus that were not readily available in many of their district schools. These areas are best covered using question answer techniques and the environment around.

> …there are some topics which you need not move very far; even you need not involve students. There are some you can collect the materials around the school. There is some where you have the conventional apparatus or materials. There are some areas where you know you will not even need, you know you don't have any, in some of the topics; you don't have any of the apparatus and resources. For instance, if you are talking [about] metals you have some simple things like when you are asking students why is this so red, why is this color becoming so red with time? You are trying to bring in about iron III. So in such kind of topics there are areas where you can even use where you are, the science where you have the conventional ones and the [environment].

Another topic in which the participants used improvised materials to teach or conduct experiments was that of enthalpy changes. In this topic, experiments to determine the heat change when a certain amount of fuel is burnt, teachers used a spirit lamp as a source of heat. Although it was not possible to determine the actual heat change, the participation of the students in such activities was worthwhile. It indicated that teachers were able to teach science concepts in rural schools lacking conventional apparatus for experimental work in chemistry. As Saba put it:

> There are other topics like in exchanges, whereby you are supposed to calculate for instance or find out the heating value of a particular fuel. It can equally be measured using local examples like you can use a spirit lamp. You can mix it with some kerosene and then you weigh it before, you burn certain quantity of the fuel, and then you weigh it again. You are able to get the mass of fuel, which was burnt. And you will be able to calculate the heat change during that process. Because by assuming that if we knew density of the fuel for instance, we will be able to get the energy in terms of kilojoules, and then we are able to calculate this particular mass of fuel that we burnt to be able to give us work. So students can be engaged in such activities when such a topic is being handled.

Teachers went steps ahead to ensure that they taught their chemistry units even though their schools lacked conventional facilities. Where the required materials were not available in school, the teachers had either to buy cheaper versions of the brand or borrow from places they were available. In this regard, Sita said:

> Yeah, I think that one let me add because there are times like the [weighing] even in machines; you have no real way of helping you in determining the mass. So these are very unique areas and the machine as much as it is expensive you can see how it depends

> on the topic, there are some topics where you might be handicapped especially when you have not acquired such kind of machinery. However you must go deeper and look for either cheap machine or borrow when you are going to handle that topic, go out for it to another institution, which is actually having maybe that has the machinery.

The topic on salts was covered by drawing examples from the students' experiences with salts in their homes. The students were familiar with the common salt (sodium chloride) and the fertilizers used in their farms. In handling this area, Nane said:

> Another topic like, I can say, is salts, their preparation, you know, this one salts, the students are familiar with like now we have salts like sodium chloride which they use in their homes, we have fertilizers which they use in their homes. So at least they are aware and when we use these examples during these topics, now the topic is understood fairly well because the students seem to know what we can do with the salts.

However, the students had problems on preparation of salts. The teachers prepared small-scale amounts of some salts in the laboratory in cases where the gases involved were dangerous to work with. For instance, they prepared sodium chloride through direct reaction of a small amount of sodium with chlorine gas prepared in a small scale. This approach attracted the attention of the students, who enjoyed learning more about salts. Saba commented:

> The only problem is when it comes to their preparation; you know they would like to know how this sodium chloride formed. Like now, there is this reaction of sodium with chlorine, if you can prepare a small amount of chlorine, then you react it with sodium metal. The reaction is so nice that it can attract their attention with students and they will enjoy the topic, having that direct method of preparing salts. So, at least we have these topics where we can always get locally available examples.

The teacher made the teaching of chemistry units relevant, interesting and enjoyable to the students through use of small-scale experiments and local examples/ and materials.

Role of the district in-service education resource center. The district in-service education resource center played an important role in promoting the teaching and learning of science in the district secondary schools. It had adequate facilities to implement the secondary school science (biology, chemistry and physics) curricula. The teachers from neighboring schools were free to visit the center and perform experiments for their students or borrow materials to go and use in their schools. The borrowed items were to be returned to the resource center after use. As Saba put it:

> …I happen to be in a school which is a district "training" center and what I will be able to say is that it has been made very clear to all other schools that particular facilities are there in the District "Training" Center. Actually for the "O" level syllabus, all the facilities to perform experiments have been availed in the school. And the schools are aware that any experiment they are not able to perform in their own schools and feel they should do it, they are free to go to the District INSET Center and the materials will be availed to them and they perform the experiments. So the district "training" centers are playing a very big role in ensuring or promoting the teaching of science and mathematics in our district.

Although the distance of some schools from the resource center was big coupled with poor infrastructure, the teachers found the center useful in promoting and assisting them to perform experimental work in science in their schools. The establishment of the resource center was one of the objectives of the SMASSE project that had been achieved. Sita had observed:

> …my school happens to be one of the schools which do not have enough facilities and I am the chemistry teacher and at the same time I am a district "trainer". Our center is playing a very big role because especially the distance from my school to the center is very big, about 30 kilometers. That is a big distance but what I do is when I want some of the either apparatus or some of the chemicals for use in my new experiment which I can't afford to improvise or which I don't have, I write down the request and send my lab technician. And so those things we use them and return them. I think our center is playing a very big role because they can now expose every school, since we have been borrowing chemicals and apparatus. It is very comfortable. So the SMASSE has really, that's one part, which we should give a nod to SMASSE.

However, the one center for the whole district was not very useful to many schools which were far from the center. More resource centers for in-service teacher education were required to ensure that the facilities were easily accessible by all schools. As Nane argued:

> Yeah, that's correct but here we have only one center with all the materials and apparatus being at one point. Now some schools would like to use them but then, at least there is this problem of transport and somehow in some schools that we have around, the teachers teaching chemistry are not "trained". So they don't have that spirit of performing experiments. So they will not even go to even request for those. So me I would say it

> would have worked so well if we could have had at least three centers, which are similar in various schools. Like now if we could have around three of them, so that at least they could be reached easily.

The other way that the project would enhance student achievement in science was by providing at least the basic science facilities to all schools. The project also needed to address the issue of having unprofessional teachers who mostly covered their chemistry content teaching theoretically.

Since not all teachers had been in-serviced in the district, more efforts were needed to ensure that all chemistry teachers had positive attitude towards having student-centered activities. Teachers should plan and implement practical-oriented chemistry lessons that involve students and provision for lesson evaluations. Nane added:

> Then at the same time I think the teachers themselves, you know we have those ones who will like to perform experiments but then we have these ones who don't, and they especially teach chemistry in theory. So that at least such teachers are the ones who need to be a bit changed and be made to know that with practicals understanding becomes easier.

The SMASSE project had succeeded in establishing the district resource centers for science teachers and many teachers in-serviced on ASEI-based lesson plans and implementation focusing on the PDSI approach. However, the numbers in-serviced alone was not the only criterion to assess the enhancement of the teaching and learning of secondary school chemistry. More qualitative research-based evidence was required for each school, individual teachers, and the students to assess the impact of the SMASSE in-service education on student achievement in chemistry within the district.

The SMASSE Project: Issues for consideration by planners and administrators. The participants were satisfied with the hands-on and minds-on activities they were exposed to during their SMASSE national in-service education. In particular, the participants found the idea of improvisation appealing to them because of its applicability to their schools which lacked facilities and materials for effective chemistry teaching and learning. As Sita put it:

> For me it is improvisation, the kind of the exposure to the various materials and even acquisition of those facilities because sometimes we think of going to buy the materials when we have the materials around. I think if we can dwell more on that like when we went to the, when we were undergoing the “training”. One of our counterparts from Japan, I think brought up that idea very well and we had to see the things we have at home are the things for carrying out, I think we can get that. The “training” can emphasize on that. I think it would make everybody comfortable.

More efforts were required to ensure that the project was sustained. The teachers involved in the education of their colleagues during the in-service education sessions need to be motivated, an area that the SMASSE planners and administrators seemed to ignore. The in-service educators ought to be recognized either through staff development units or issuance of valid certificates, and where applicable promotions awarded on merit to such personnel. Saba argued:

> I think SMASSE is a program, which needs to be there, and needs to be sustained and the “trainers” here are playing a very key role. One way to improve this program as said, there is need for the administration both sides, the Kenyan Government and the Japanese Government to see how they can motivate these “trainers”, those who are involved in the actual “training”. They need to be motivated. There are many ways of motivating them. One way they are doing it is that they are giving them certificates for the “training” they have undergone but as we had argued much earlier on, there maybe need for them to be considered in terms of promotions or upgrading them in one way or the other. I think there would be more motivation and it may work well for the project.

A successful in-service education is that which is available to teachers all-year round. The SMASSE in-service teacher education needed to be sustained and implemented all-year round in the district. This meant that the district in-service educators were to be more involved in organizing and implementing the in-service programs all the year round. One of the implications of this development was that the district in-service educators were to be relieved from their school duties to be fully involved in the district in-service programs for science teachers. The district in-service educators also needed to be supported with means of reaching every school to evaluate the impact of the in-service education programs in student achievements in chemistry. As Sita argued:

> We have gotten a very important aspect, which I think will remain if there is anything good, which must come out, it, should also be looked at. Now we are 16 "trainers" in our district, four in each subject and we have about 170 schools in our district. All those schools need the "training"- they need constant in-services. What is wrong with involving those teachers giving them that opportunity so that they embark on that, they are there, they affect various divisions, small units? The same "training" with district "trainers", they are relieved of their duties in their schools even the means of reaching those divisions and being closer to the schools, going even to the schools themselves. What wrong with the district with 170 schools having a center, a very good center, and these teachers are coming there, they have their own seminars? They can even start as a group.

Another way of enhancing in-service teacher education was to expose the in-service educators to what happens in other areas. The excursion to other districts was to facilitate exchange of ideas on chemistry teaching and how to strengthen the in-service education in their respective areas. Provision of computers for use by the in-service educators was also one way of enhancing the implementation of the district in-service programs. In this regard, Sita added:

> They (participants) have means of traveling. They can go maybe to watch such programs in mwema province: Buyema, Kamanga to see their counterparts. Sometimes those counterparts come. These ones embarked on and since we are in a technological era, computers, we need these fellas and they will see wonderful results. I am very sure if these teachers are given that chance, the district "trainers", rather than just taking it [lightly], then that is the way we see it.

On the other hand, Nane felt that the area that needed more emphasis in the in-service teacher education was improvisation. The area on improvisation was important because many rural secondary schools had inadequate provision of science education resources to effectively implement the national science curricula in Kenya. Nane said:

> …the area where they need to emphasize on is improvisation so that when it comes now to schools those teachers who may see that they don't have materials, they don't have apparatus, they should be "trained" on how to improvise.

Nane concurred with his colleagues that there was need to relieve the district in-service educators from their school work to fully embark on the in-service education programs. The in-service educators needed more time to educate their colleagues on improvisation of teaching aids in chemistry and where applicable help teachers to be able to conduct class experiments they feared to perform in schools. The in-service educators had gained tremendous knowledge and experience in performing various experiments in the chemistry curriculum and were able to use improvised materials to perform these experiments where the conventional apparatus were inadequate or not available. Nane put it:

> …these district "trainers" need to be relieved of their work in schools so that they are now able to go round schools and even "training" these other teachers on improvisation. And they can also encourage these teachers when maybe they teach them. They can even give these teachers, the "trainers", time to go and even perform experiments with their experience so that at least these teachers get used to performing the experiments, even when the materials or apparatus are not conventional.

Kenya is an examination-oriented country with a national curriculum. The use of improvised materials in performing experiments in chemistry was likely to disadvantage students who had to perform experiments in the national practical paper using conventional apparatus. To be awarded at least a credit (grade) pass in any science subject, a candidate had to pass the practical paper regardless of the high scores in the theory papers done. However, the participants were more concerned with students' understanding of the scientific concepts and be able to apply them after school. Many of their students were in rural district schools compared to provincial and national level status schools that were well endowed with science facilities. As Sita argued:

> The word improvisation, I think sometimes we array to the examinations given in this country but in actual sense, the teaching of the science should bring out somebody who is aware of the environment, the current development in terms of technology. This fella is going to go home and if this child does not pass the examinations very well but is going to go home there, he is going to have these plastics exposed there. This fella can use some of this wastage to even use as fuel. So we are talking of this kid upgrading his

> skills. So the idea of improvisation, this is where these kids are going to get their knowledge from. So it is a very important aspect in terms of learning.

Sita's argument was strongly supported by Nane, who in turn commented:

> Now like I happened to be somewhere we had science congress and I saw a boy melting his broken vessels and modeling them into a plate. And you could say they were also very crude, but then if they can make use of those materials and they can make a plate that can be useful, I think that way we are encouraging these boys and girls to actually use these materials. We use the materials so at least even if you are talking of improvisation here, you find out that the students are made aware of the use of these materials so that they can make use of these materials and even manufacture some of the things they need.

Although the vapors can be toxic and carcinogenic, the ideas of having students learn science using locally available materials was commendable. It is through such explorations that the teacher can lead the students in discussions involving safety precautions in scientific activities.

There was need for the project planners to ask themselves why many of the in-serviced teachers in the district were either abandoning the project, or transferring from the district, or leaving for further studies at the universities. Was the SMASSE project in a position of providing the teachers with the motivation and science education that they were going for elsewhere? On the exodus of the in-serviced teachers from the district, Nane commented:

> One thing is the kind of recognition that we received. Now the schools were not ready to contribute to the SMASSE account for the "training". And the way the "trainers" are actually "trained", the way they are received when they go for "training". Now we are given work if you are doing it and at the same time the teacher in school wants you for teaching. So somehow you will see as if you are not very important. Whatever work you are going to do is not important to the district. That is why some of them have pulled out even those who have gone for further studies, it is because of the, you know we are given a certificate and this certificate is not actually, it does not change your grade. So somehow you see if you go for further studies and get your degree, now you can easily be promoted. So that at least such kinds of things have discouraged some of the "trainers".

Sita, on the other hand, wanted the government to be fully involved in the in-service education of teachers. In his view, the district in-service educators were contributing considerably to the enhancement of the teaching of sciences in secondary education. However, the government seemed not to recognize their efforts. They were just being treated like any other employee or teacher in a secondary school. Sita wanted the government to assist them to realize the program goals in their district. He said:

> I think our government needs to look at that very seriously because I think either some of those ones who are implementing there somewhere are those who [inaudible] because us at the ground we find it very important. We are now manning a population of over 14,000 students in our district. A district with about 170 secondary schools and these 16 "trainers" if they were given some promotion, recognized, given an office, our district can manage.

The district in-service educators needed to be mobile to be able to reach all teachers in the district. They felt that taking the in-service education to the teachers was more effective than waiting for the teachers to enroll for the programs. Sita added:

> Just if they have so many Landrovers running around, if we can be given a specific office, people there with a driver and we are told so and so [audible] we divide ourselves going into the schools. We go to the school itself we see the problem. I think there, you will not find anybody trying to run away from the "training" from the district.

Promises made in an in-service education program ought to be respected by the issuing authorities. It appeared as if the educators were promised favorable terms which were not implemented for the whole duration of the pilot project. As Sita put it:

> One of the things is the approach of all the in-service programs, some of them have not seen the importance, some of them I feel those ones are the problem areas. That's why we are here because they could have taken the action; remember this was in the memorandum of understanding initially when it was being launched that the teachers who were going to be the district "trainers" will be moved by one grade something that has not been effected. So that's something we the stakeholders didn't take into account. Although we as those who have remained, who have not maybe moved out to further education or to go to other areas, we are still waiting.

The participants were still waiting for their recognition from the authorities concerned. They still felt that they had a role to play as district in-service educators. They argued that their intervention on chemical education issues were more effective compared to the quality assurance and standards officers (school inspectors) who have continued with the colonial style of going to schools and looking for teachers preparation documents. According to the participants, these officers had no time to advice or exchange ideas with the teachers on how to enhance the teaching of science in schools. The efforts of quality assurance and standards officers were likely to be enhanced if the district in-service educators were part of their team to schools. Nane said:

> And we know like now in the Ministry we have inspectors, these people when they go to the schools what they look at is maybe the normal documents like schemes of work and they don't even advise on how to perform certain experiments where a teacher has a problem. So, I was feeling that together with these inspectors, the district "trainers" should also be involved. So that when these inspectors go to schools, they are accompanied with district "trainers" so that if a teacher has a particular problem somewhere then this district "trainer" can always advise with the teachers and I think it would be fair. So if we can be accommodated in that inspectorate.

From the focus group discussions, it can be argued that having full time personnel in the district in-service education resource center was a noble idea if the in-service programs were to be sustained all-year round. Those recruited as district in-service educators needed recognition from the project planners and administrators, and their employer because they were heavily involved in enhancing the teaching and learning of chemistry in the whole district.

CHAPTER 7

COMPARISON ACROSS THE MULTI-SITE CASES FROM SIMBA AND CHUI DISTRICTS

In this chapter, multi-site case comparisons for the participants (Moja, Mbili, Tatu, Nne, Sita, Saba, Nane and Tisa), who were teaching in different school settings (boys' boarding (BB), Girls' boarding (GB), mixed boarding (MB), and mixed day (MD)) in Chui and Simba Districts, are presented. The comparisons are based on the participants' individual and focus group interviews, class observations and teacher reflections.

The participants' professional and teaching backgrounds are summarized in Table 5.

Table 5

Summary of the participants' teaching background

District	Name	Sex	Highest certificate	Teaching Subjects	Years taught	School- type and provision of science facilities	In-serviced	Other duties
Simba	Moja	M	B. Ed (Sc.)	Chem./ Math	13	BB (provincial) -Excellent facilities (DRC)	National	HOGC
	Mbili*	F	Dip. Sc. Ed	Chem./ Math	31	MB (provincial) -good facilities	National	HOGC
	Tatu**	M	Dip. Sc. Ed	Chem./ Math	19	MD (district) -fair facilities	National	Principal
	Nne	F	Dip. Sc. Ed	Chem./ Bio	15	BB (provincial) (DRC) -Excellent facilities	District	HOC
	Tano*	F	B. Ed (Sc.)	Bio/chem.	10	GB (provincial) -Good facilities	District	HOS
Chui	Sita	M	B. Ed (Sc.)	Chem./ Math	20	MD (district); fair facilities	National	Principal
	Saba	M	Dip. Sc. Ed	Chem./ Math	14	GB (provincial); very good facilities (DRC)	National	Acting Principal
	Nane	M	Dip. Sc. Ed	Chem./ Bio	17	BB (provincial) -good facilities	National	HOC
	Tisa*	M	B. Ed (Sc.)	Chem./ Math	20	MB (provincial), -fair facilities	National	Principal

Key:

DRC: District In-service Resource Center; HOGC: Head, Guidance and Counseling; HOS: Head, Science; HOC: Head, Chemistry.

(*) Mbili, Tano and Tisa were very new at their schools, having been transferred by the Teachers Service Commission at the start of the term in January 2004. Tano was originally teaching and in-serviced in Chui District. She replaced Mbili in the Girls' boarding school on transfer. Tano, who was educated as a cluster in-service educator, became a district in-service educator during the fourth cycle of the in-service program replacing Saba who was pursuing school-based degree courses at Kenyatta University. On the other hand, Tisa taught and headed a district level mixed day secondary school during the entire SMASSE in-service education project duration in Chui District.

(**) At the inception of the SMASSE project, Tatu was teaching and a department head in a provincial secondary school, which had excellent science facilities. He was later transferred and taught in the same school with Moja and Nne before he was promoted to become a school principal in a district level secondary school.

Seven of the selected teachers were in-serviced at the SMASSE National In-service Education Unit and two had been in-serviced at the district level. All the teachers had been and still were teaching in the pilot districts. All the participants were highly experienced teachers with at least 10 years of experience. Four of the participants were principals and three were department heads, while two were subject heads. The participants had similar expectations when they joined the in-service program. They expected to improve on their teaching skills, advance their career through further studies leading to promotions and were eager to share their experiences with other teachers in their respective districts and schools. They anticipated that improved teaching skills were to greatly influence the teaching-learning environments in their schools and improve their students' performance in the national examinations.

In this summary of the findings, a combined comparison of the participants' experiences and beliefs about their chemistry unit lesson planning and implementation following in-service programs are provided (Tables 6, 7, 8 and Figures 5, 6, 7). The findings on teacher experiences and beliefs about chemistry unit lesson planning and implementation following the SMASSE in-service education programs in Kenya can be envisaged as an interaction between three categories (Figure 5). The categories influence each other in enhancing classroom student activities in chemistry following in-service teacher programs. Teacher beliefs and experiences on in-service teacher education programs are likely to affect how teachers perceive in-service education program sessions and the choices or decisions they make on the in-service education materials/methods during their classroom practices. The teachers may choose to apply, in their classrooms, what they learn from an in-service program or ignore it depending on how it relates to their pre-existing or changed beliefs. The interrelationships between the participants' beliefs about SMASSE in-service programs, in-serviced teachers, and in-serviced teachers' classroom practices are presented in Figure 5.

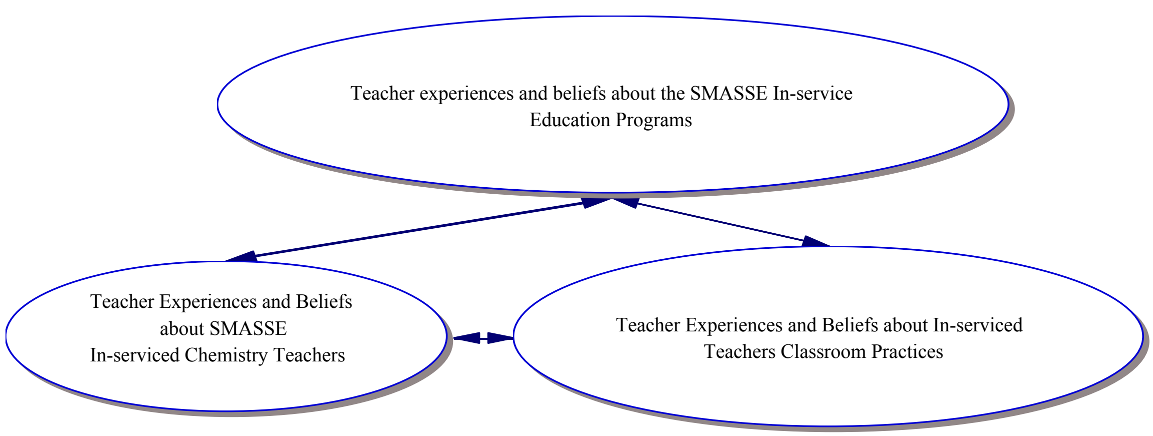


Figure 5. Teacher experiences and beliefs about chemistry unit lesson designs and implementations following in-service programs.

From the categories (Figure 5), there emerged other themes. The participants' experiences and beliefs about the chemical in-service education programs were grouped into their expectations, benefits (or satisfiers), and the unmet expectations or constraints they faced (or dissatisfiers) following the in-servicing (Table 6). The expectations are the teachers pre-existing beliefs about what an in-service program ought to offer in terms of pedagogical content knowledge and recognition by the concerned authorities such as the in-service providers and the employer. Teachers expect to be compensated for the efforts they put to improve teaching and learning skills. In this study, the satisfiers maybe seen as those factors that made the teachers appreciate the in-service education programs to enhance chemistry teaching and learning. The satisfiers are, therefore, the benefits the in-serviced teachers received from the in-service courses. There are other factors that hinder successful implementation of in-service programs and improved teaching and learning of chemistry in schools following in-service courses. These factors, herein referred to as dissatisfiers, were seen to be in form of the participants' unmet expectations and the constraints they faced when implementing the chemistry curriculum and applying the learned knowledge from the in-service programs. On the experiences and beliefs about the teachers' in-service educated teachers' category, the codes grouped into expectations, satisfiers (benefits) and dissatisfiers are presented below (Table 6).

Table 6

Participants' expectations, satisfiers and dissatisfiers about the SMASSE in-service chemistry teacher education program

SMASSE In-service Chemical Education Program
Teacher expectations: • Improve the quality of teaching secondary school chemistry through collaborative efforts • More schools to be involved and have more students participate in science • Students' chemistry national examinations results were to improve after five-year in-service program • Issuance of certificates of SMASSE project in-service educators after the 4-cycles of in-servicing *Satisfiers*: • ASEI movement/PDSI approach to chemistry teaching/learning was very important • SMASSE Chemistry lesson plan format (with columns for objectives, teaching/learning activities, resources, remarks parts) was teacher friendly • Implemented a chemical education in-service curriculum in the districts similar to that they were in-serviced in at the national level • Established national and district in-service education resource centers *Dissatisfiers*: • Non recognition of the in-serviced educators through issuance of educators' certificates and promotions • Some in-service educators at the national in-service resource center were inexperienced • One district in-service resource center not adequate, more were needed • Reference materials at the district resource center were on high school chemistry content and not on science or chemical education • Non in-servicing of all teachers, principals, and laboratory technicians on how to enhance implementation of chemistry curriculum in schools • Inadequate provision of science facilities in the district schools • District cluster in-service education was uneconomical to implement because of poor infrastructure in the rural schools, large distances between the many schools and inadequate finances in the district in-service kitty • Non support of district chemistry teachers' associations by the SMASSE project

It is shown (Table 6) that the participants had expectations about the in-service programs. Some of the expectations were met (the satisfiers) while others were not achieved during the in-servicing (the dissatisfiers). While the satisfiers were likely to lead to improved teaching and learning of chemistry, the dissatisfiers seemed to have a negative impact on the enhanced teaching. The in-serviced teachers had their post-in-service education program beliefs and experiences. The in-service programs might have made the teachers to change their pre-existing beliefs about teaching and learning of chemistry or not. A summary of the participants' reasons for participation, benefits from the in-service programs and the constraints they experienced implementing the chemistry curriculum, as district in-service educators, is presented below (Table 7).

Table 7

Participants' reasons for participation in the in-service courses; and the benefits and constraints the SMASSE chemistry in-service educators experienced

SMASSE District In-service Teacher Educators

Reasons for participation in the SMASSE in-service courses

- To learn new approach to teaching and improve performance in chemistry
- Learning through interaction with counterparts would be beneficial to them
- To be exposed to some chemistry teaching instruments not available in their schools
- Learn on how to change students' negative attitudes towards learning chemistry
- Wanted to be in-service educators because the District Education Offices wanted all science teachers in-serviced

Satisfiers (Benefits) from the SMASSE in-service programs:

- ASEI movement/PDSI approach to chemistry lesson planning and teaching/learning were very important
- Exchanged chemical education ideas through interaction with counterparts from within and other districts
- Successful implementation of a chemical education in-service curriculum in the districts similar to that used in the national level
- Having well equipped and useful district in-service education resource centers

Dissatisfiers (Constraints) on the SMASSE in-service programs activities:

- Non recognition of the in-serviced educators through issuance of educators' certificates and promotions
- Being in-serviced by some inexperienced educators at the national in-service resource center
- Inadequate district in-service resource centers to cater for the many schools that were far apart and were poorly equipped with science materials
- Non availability of pedagogical materials in chemical or science education in the resource centers
- Many teachers had not been in-serviced in the district.
- Non-cooperate principals who felt that SMASSE activities were expensive to implement in school.
- Increased workload as classroom teachers, heads of department or schools in addition to in-servicing teachers in the district

From Table 7, it was observed that the in-serviced teachers had reasons for participating and had benefited from the in-service programs, but had constraints that seemed to dissatisfy them in implementing the chemistry unit lessons following their in-service education.

The in-serviced teachers continued to teach chemistry in schools. They planned and implemented chemistry unit lessons based on the SMASSE's ASEI movement and PDSI approaches. The participants' experiences and beliefs about how they planned and implemented the chemistry unit lessons following their in-service courses are presented in Table 8

Table 8

Participants' teaching practices and constraints on chemistry unit lessons' implementations following in-service education program

Teachers' classroom practices following SMASSE in-service program

Satisfiers (Improved teaching practices):

- Prepared lesson plans and taught chemistry unit lessons based on SMASSE's ASEI movement and PDSI approach
- Implemented student-centered activities in all their chemistry unit lessons
- Improvised teaching and learning materials using locally available materials
- Utilized self-, students'-, and colleagues'- lesson evaluations in planning and implementing subsequent chemistry unit lessons
- Taught some of their chemistry unit lessons using borrowed chemicals and equipment from the district in-service education resource centers

Dissatisfiers (Constraints):

- Examination oriented national chemistry curriculum
- National chemistry examinations' questions are not based on inquiry activities and improvised materials propagated by the SMASSE project
- Teacher recognition was based on his/her candidates' overall performance in the national examinations and not students' added values in the poorly equipped district secondary schools
- Teaching with unqualified professional teachers
- Teaching in a school where the head teachers thought that SMASSE activities were expensive to implement in the district schools
- Teachers' increased workloads in addition to other school duties(heads of department or schools) and district in-service educators

It was noted (Table 8) that the participants had improved lesson planning and teaching approaches (the satisfiers) but had constraints to their classroom practices (the dissatisfiers). The broad examinations-oriented national chemistry curriculum, dealing with unqualified professional teachers and increased teaching workloads hindered the in-service educators' planning and implementation of the chemistry unit lessons. The satisfiers and dissatisfiers experienced by the in-serviced teachers were likely to influence the participants' lesson preparations and implementation. The dissatisfiers, if left unattended by the concerned authorities, seemed to affect the teachers' actions and choice of chemistry teaching/learning activities. Dissatisfied teachers were likely to resort to their old teaching practices regardless of the in-serviced courses attended.

Prior to the in-service courses the participants felt that they had been thoroughly prepared to teach chemistry in their respective teacher education institutions. The participants had been teaching chemistry using the traditional methods: theory followed by a practical session or vice versa. The teachers pre-existing beliefs about their pedagogical content knowledge level were likely to influence the way they made sense of the new strategies or approaches of teaching chemistry. The teachers were found to have experiences and beliefs about their pedagogical content knowledge in designing and implementing chemistry unit lessons prior to and following the in-service programs; and their classroom practices. The experiences and beliefs are grouped under the satisfiers (pedagogical factors that made the participants to appreciate the role of in-service programs in enhancing teaching and learning) and dissatisfiers (factors that hindered the participants enhancing of chemistry teaching and learning) as shown below (Figure 6).

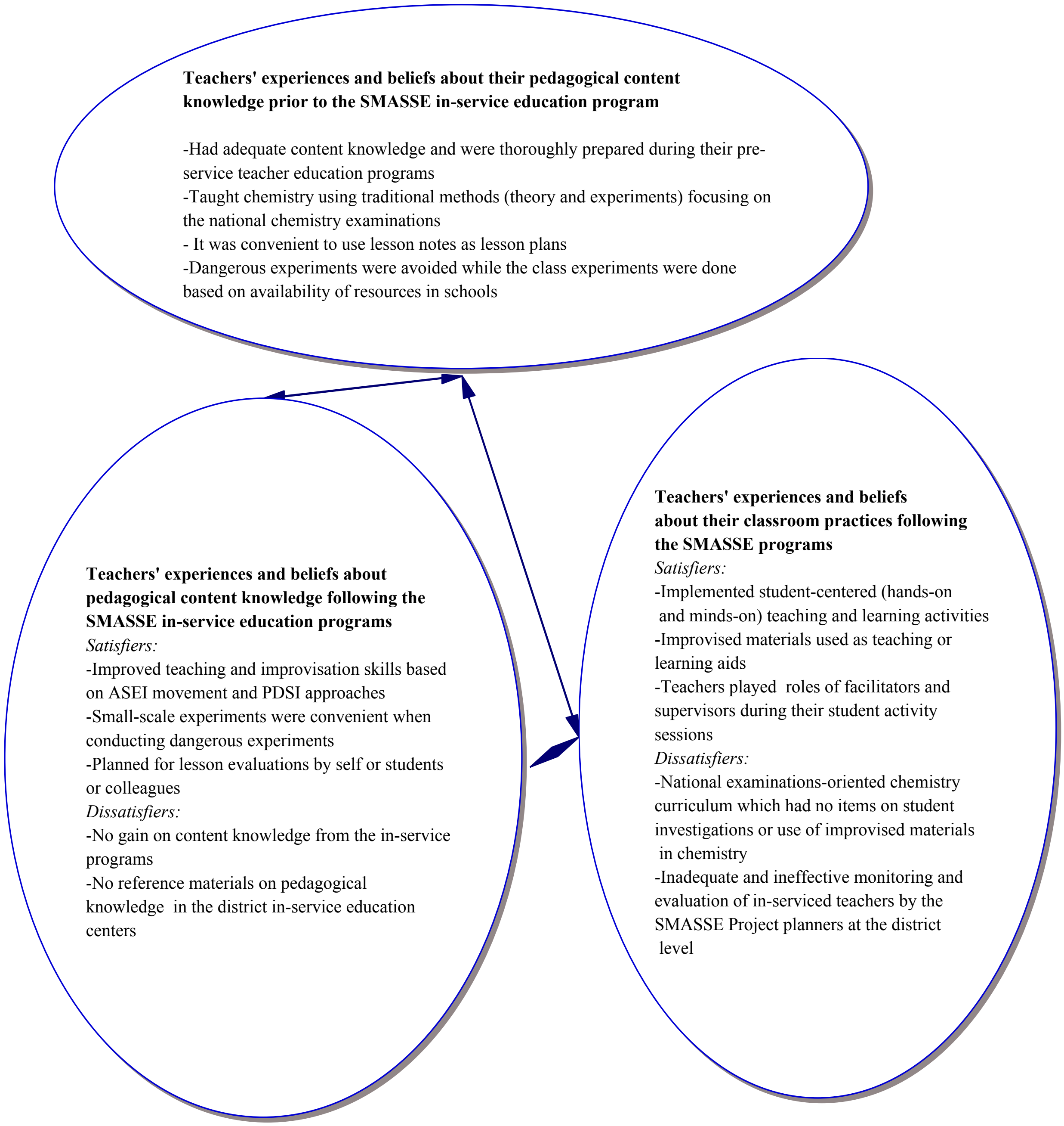


Figure 6. Teachers' experiences and beliefs, in terms of satisfiers and dissatisfiers, about their pedagogical knowledge following the in-service program

Prior to the in-servicing, the participants believed that they had adequate content knowledge and were well prepared to teach chemistry from respective teacher education institutions. The disparity in the provision of science facilities in schools required different approaches to chemistry teaching in such schools. It was observed (Figure 6) that the participants improved on their teaching and improvisation skills. They were able to prepare and implement student-centered activities (satisfiers) relevant to their immediate environments. However, their improved classroom practices were hindered (dissatisfiers) by the examination-oriented chemistry curriculum, lack of pedagogical reference materials in the resource centers, national examinations' chemistry questions, and lack of effective monitoring and evaluation of the in-service activities by the project planners.

All the participants, who were SMASSE chemistry in-service educators, were full time classroom teachers during the project duration. The cascade system of in-service education was expected to enhance the teachers' teaching skills regardless of the level of in-servicing. The same chemical in-service education curriculum was used at the national, district and cluster levels to ensure transferability of the same pedagogical knowledge to the school level.

From the data collected, two participants were in-serviced at the district level while the other seven were educated at the national in-service center and implemented in-service education programs in their districts. The interactions that the participants had during the in-servicing and in schools seemed to suggest that the participants had similar experiences and beliefs about the implementation of the SMASSE project activities in their respective districts. A summary of the comparison of their experiences and beliefs about designing and implementing chemistry unit lessons after the in-service education programs (Figure 7).

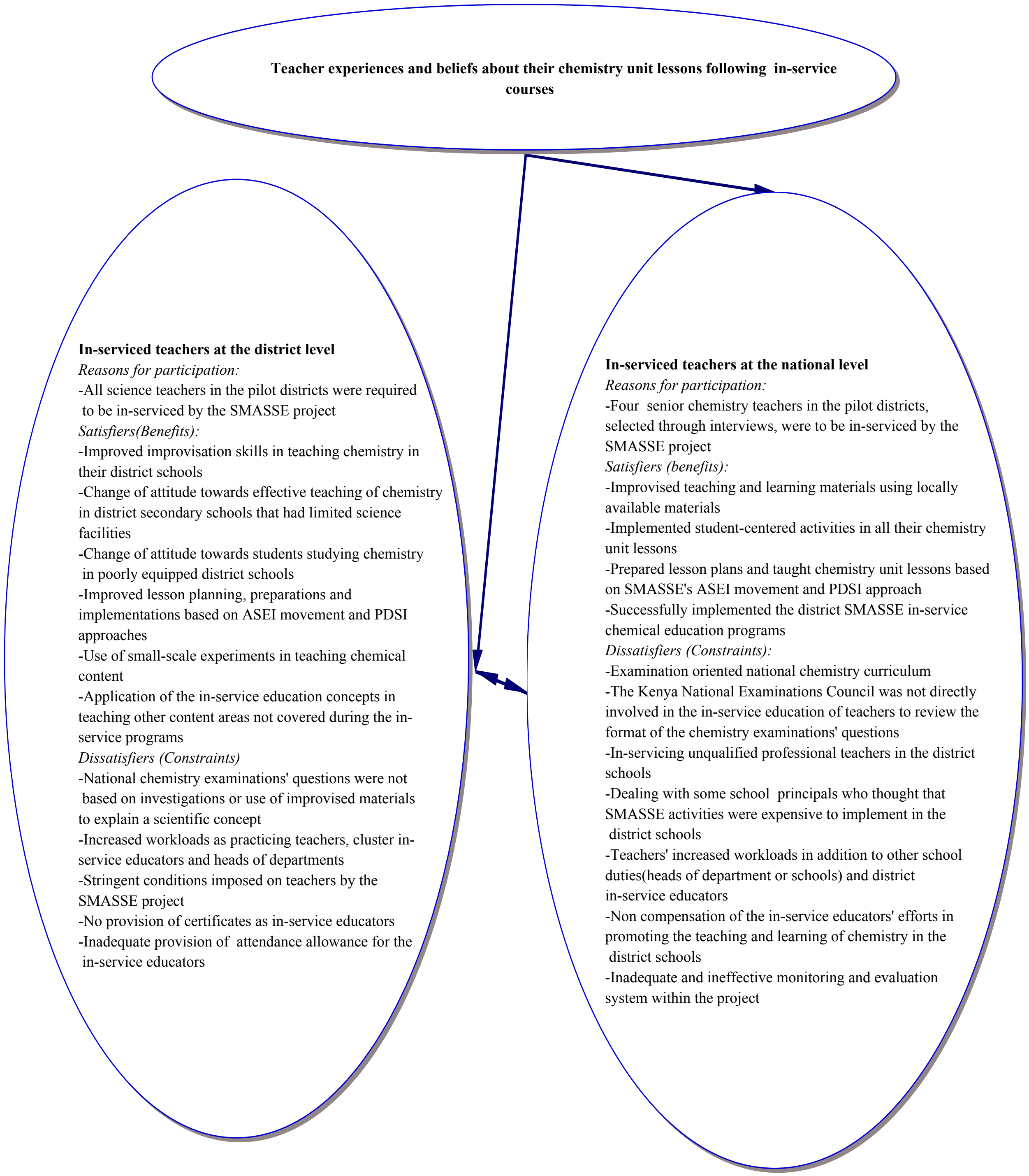


Figure 7. A comparison of district and cluster educators' experiences and beliefs, in form of benefits and constraints, in lesson planning and implementations

Reasons for participating in SMASSE in-service courses. It was seen (Figure 7) that the seven district and the two cluster in-service educators had experiences and beliefs about the

SMASSE in-service education that were similar. The cluster in-service educators had joined the in-service programs because it was a requirement from the education authorities that all science teachers in the pilot districts were to be in-serviced by the SMASSE project. They volunteered to be in-serviced as cluster in-service educators. The district in-service educators were among the four senior chemistry teachers selected from each pilot district, through interviews, to be educated at the national in-service education center on how to implement the SMASSE activities in their respective districts.

The satisfiers (benefits) from the in-service education courses. The participants benefited in terms of improved teaching methods and improvisation skills (Table 7). They implemented student-centered learning activities and planned for their chemistry unit lesson evaluations. All the participants felt that they had greatly benefited from the in-service program in terms of teaching skills, change of attitude, lesson planning and preparation, and implementing student-centered lesson plans. The teachers were able to accommodate gender issues in their schools and encouraged the girls, where applicable, to pursue science subjects in school. The teachers were now able to improvise teaching learning gear using locally available materials and resources. They involved their students more on hands-on, minds-on and inquiry based investigation activities.

The teachers had made changes in the format of their chemistry lesson plans that greatly moved away from the traditional formats they had been prepared in during their pre-service teacher education courses. They had come up with a teacher friendly lesson plan, in which they had a column for activities, teaching notes/teaching learning points, and a remarks part. According to the participants this type of lesson planning, even though it consumed a considerable amount of time planning and preparing, they found it easier to implement student-centered activities. The participants were able to involve different students during class demonstrations and improvised materials depending on the weather, class size, and the schools' settings. The improvised materials were sometimes different from those they had made during the in-service program. They were to apply the knowledge gained during the in-service in improvising teaching and learning materials in chemistry.

The participants were able to plan for their lessons' evaluation in advance. Some had even modified the lesson evaluation form they had prepared during the in-service programs. The continuous lesson evaluations were either done by the participant him/herself or the students or colleagues where it was applicable. Students gave feedback using evaluation worksheets or plain papers. The lesson evaluation feedback was used to improve on subsequent lessons the participants taught in their classes.

The dissatisfiers (constraints) encountered by the in-service educators. The participants' expectations of having advanced certificates in science education and having their efforts rewarded based on their involvement in professional development activities had not been achieved. They were dissatisfied with the SMASSE project in-serviced teachers' motivation plans. Although the project planners felt that the implementation of the in-service education was successful, the participants argued that many teachers had not been in-serviced. It was also difficult to in-service unqualified teachers together with professional chemistry teachers in the rural district schools. The participants' involvement in professional activities had increased their workload with no compensation in any way. The increased workloads, as in-service educators, and the national examinations-oriented chemistry curriculum were likely to affect the SMASSE project activities in the districts and the school level. The constraints in the provision of in-service education to improve teaching and learning left the district in-service program implementers dissatisfied with their participation in the promotion of chemistry education in their districts.

Planning and Implementing Chemistry Unit Lessons

The Periodic Table. The participants believed that Periodic Table was the core of chemistry. When handling this topic, the participants felt that a teacher has to cover first the elements' valences, secondly cover the formulae of compounds, and thirdly the chemical compounds. The participants made their periodic table lessons concrete using student activities. Students need to be thoroughly prepared in this area in order for them to understand the chemistry of various elements. This requires appropriate teaching and learning approaches in schools. Teachers ought to think about teaching/learning activities in the trends and patterns in the element properties. Teachers have to prepare charts or/and have conventional charts appropriately hanged in class. When teaching the periodic table using charts, the teacher should have a pointer to highlight the parts of the periodic table being addressed.

According to the participants, teachers ought to plan for lesson evaluation in advance as they prepare to teach the periodic table. Continuous feedback during lesson implementation helps the teacher to know his or her students level of understanding and which students need more attention in given areas that are being taught. The participants found it appropriate to use letters to represent elements when teaching the periodic table. Use of letters to represent the elements made the students to comprehend the chemistry behind the periodic table rather than cramming the elements' chemical facts. The teachers used question answer techniques to cover work on the periodic table. They also used different colors for different family patterns/elements, for example, metals/non metals, transition elements, alkali, alkaline earth metals, and halogens.

The participants made the topic understandable to the students by using models, which were either conventional or improvised.

The "mole concept". The participants felt that the topic on the "mole concept" scares students, right from the start. However, the participants were able to address the students' fears by not telling them that they are starting the topic on the mole. The students come to learn later that they are studying the "mole concept" as they discuss basic units in their daily life such as a dozen, then relate to the mole as a quantity of material equal to $6.0X\ 10^{23}$ particles.

The participants concurred that the "mole concept" was very important in volumetric analysis experiments on titration. Many experiments have to be done to enhance student understanding of the "mole concept". According to the participants, students ought to perform an experiment at least every week and calculation activities given to reinforce students' understanding of the "mole concept" in titrations, for example, converting a given mass into moles. Practice questions also assist the students to know how to apply the "mole concept" to particles involved in chemistry such as atoms, molecules, and ions. Where applicable, some participants showed films on the "mole concept" to their classes. The films helped students to visualize the "mole concept" which they sometimes found difficulty to learn.

Electrochemistry. When teaching this topic, the participants organized activities to show movement of ions. However, teachers have a problem of which experiments to conduct on movement of ions, that is, should there be a class experiment or teacher demonstration? The participants planned for experiments that involve colored electrolytes or formation of colored products. According to the participants, there must be suitable electrolytes to reinforce learned concepts, for example, passing an electric current through molten substances and then using a salt bridge that melts easily such as potassium bromide, which produces a brown gas at the anode and silvery lead at the cathode.

The participants were able to improvise electrolytic cells (voltmeters) using locally available materials such as transparent containers that help students to observe changes taking place in them. In cases where electricity was not available in school, the participants used dry cells or accumulators as sources of electric current. When conducting lessons on this topic, the participants' students did calculations that involved the first and second Faraday's laws. The participants concurred that redox reactions were a pre-requisite to students' understanding of electrochemistry. The redox reactions involve movement of ions that are covered in electrochemistry. The participants felt that the students should be let to understand the difference between electrolytic cells (produces electric current) and voltaic cells (electric current producing redox reactions) immediately after introducing chemistry. This will make it easy for students to follow concepts in electrochemistry. The teachers can also improvise single cells with a salt bridge and perform hands-on activities on processes such as electroplating.

Organic chemistry. The participants observed that organic chemistry had many applications such as the manufacture of clothes, medicine, plastics, and useful chemicals. According to them, it is important for a teacher to organize the topic introduction well, for example, by showing the students some organic materials found within their school. This will provide students with a stimulating introduction to capture their thoughts. The teachers can also give examples of locally available materials or processes. The participants thought they did not have any problem in planning for organic chemistry activities following their in-service programs. They were able to relate school science with students' practical experiences on preparation of organic chemicals in their homes.

The participants were able to have prior lesson planning and resource mobilization unlike in the past when they collected organic materials as they prepared a lesson. They taught organic chemistry using conventional or improvised models on organic structures. However, they felt that students had difficulties studying organic compounds (such as alcohols, polymers, and carboxylic acids) and their nomenclature. There should be more exercises and activities, especially on preparation of esters and soaps. They argued that more emphasize should also be put on group activities because students motivate each other when they work in groups as opposed to individual activities. The teaching and learning of organic chemistry is made simpler when teachers use films and videos on large scale processes such as distillation of petroleum. Well planned class excursions to gasoline stations and (oxyacetylene) welding places can also enhance the teaching and learning of organic chemistry in schools.

According to the participants, chemistry should be compulsory up to junior levels and optional at higher levels. In Kenya, chemistry is compulsory in all public schools and is taught in all classes in high school in every week of a school term. Perhaps making chemistry optional in grades 11 and 12 might reduce the cost of implementing chemistry curricula in Kenya's public schools and have only those students interested in continuing chemistry oriented-careers to pursue advanced chemistry.

Constraints in implementing SMASSE's ASEI movement and PDSI approach. Although the participants had enhanced their teaching skills, lack of finances to provide adequate teaching/learning materials hindered their teaching of chemistry in the rural schools. The situation became worse in places where some principals were uncooperative towards SMASSE activities because they felt that the chemistry activities were becoming rather expensive for the schools to implement. The school heads and participants' colleagues still preferred traditional methods of teaching chemistry to that advocated for by the in-service programs. The frequent curriculum reviews required new textbooks, while many teachers practiced examination-oriented teaching. The teachers' rewards in Kenya are more based on the examination results than anything else. The in-serviced teachers had difficulties teaching chemistry based on the new approaches because students were not interested in investigation activities that are not tested in the national examinations. It was also difficulty for the participants to continue using improvised materials whose application is not tested in the national examinations. However, teachers who used improvised materials were forced either to show the students the conventional apparatus or draw diagrams of the setup of the conventional apparatus during an experiment.

The district in-service resource centers had helped many schools which lacked apparatus or chemicals to borrow them. However, teachers' laxity to return the borrowed items to the district in-service education center inconvenienced others who wanted to borrow them for their schools. There was need for the SMASSE national office personnel to support the formation of district chemistry associations for the teachers to exchange ideas applicable to their school situations. This is likely to lead to proper management of district SMASSE funds to facilitate adequate provision of chemistry teaching materials in schools.

Summary. The participants benefited from the in-service education in terms of enhanced teaching methods (ASEI movement and PDSI approach) and positive change of attitudes towards teaching and learning of chemistry in district schools with diverse groups of students in relation to socio-economic status and gender issues in science classes (the satisfiers). However, uncooperative teachers and principals towards SMASSE activities, examination-oriented curricula, non-issuance of recognized in-service education certificates, increased workloads for the district in-service educators, inadequate allowances, and inadequate and ineffective monitoring and evaluation mechanisms were found to be the constraints (the dissatisfiers) to the participants' achievement of the overall SMASSE project goals. The dissatisfiers seemed to affect the effectiveness, impact, relevance, efficiency and sustainability of the project activities at school level.

CHAPTER 8

DISCUSSION, IMPLICATIONS ON SCIENCE TEACHER EDUCATION AND CONCLUSIONS

Discussion

Designing chemistry unit lessons. In addition to the teachers' preparation of schemes of work for each term, the multi-site case studies indicated that the teachers believed that lesson planning and preparation were important in having effective chemistry teaching and learning. The participants had participated in designing a teacher friendly lesson plan format, which incorporated the teaching/learning activities and lesson notes. From the participants' interviews, observed lessons and lesson plans collected during the study, the new SMASSE's ASEI lesson plan format had provision for lesson evaluations with an aim to improve on subsequent lessons. The SMASSE's ASEI movement focused on student-centered activity lessons, experiments and improvisation to enhance the rural secondary school students' achievement in chemistry. Teachers prepared their lesson plans with their students' in mind and the availability of the teaching resources in the district schools. Previously, the teachers used to prepare lesson plans that had objectives, teaching aids/ materials for experiments, reference materials, introduction, lesson development, lesson summary/conclusion, assignment and remarks parts. However, teachers hardly used to prepare lesson plans using this format and believed that lesson notes were sufficient for the lessons they conducted (SMASE Project, 1998). This is why SMASSE in-service education emphasized the ASEI lesson plan format to enhance chemistry teaching, especially in those schools with inadequate provision of science facilities.

Following the in-service courses, the teachers were able to plan for advance collection of locally available materials they would improvise to teach their chemistry unit lessons in cases where conventional equipment were not available in school. The participants believed, and demonstrated during teaching observations, that they prepared their lessons with the knowledge of the content to teach, students, instructional objectives, resources, coherent instruction, and student learning assessment. The findings of this study on the participants' classroom practices seemed in line with the teaching strategies in science advocated for by other scholars (Chiapetta & Koballa, 2002). The participants' lesson planning and preparation was in agreement with other professional practice frameworks for science teaching (Danielson, 1996). Planning for student activities based on the ASEI movement was a great improvement on the in-serviced teachers' professional practices in Kenya.

Implementing chemistry unit lessons. From the findings, the in-service teachers planned for student-centered activities in all the lessons they taught. Unlike in the past where they taught chemistry using the traditional methods (a theory lesson following a practical session or vice versa), the in-service teachers incorporated the PDSI approach in their chemistry unit teaching. They believed that they were engaging their students in meaningful learning activities unlike in the past prior to their in-service courses. They implemented the student-centered learning activities and employed various teaching strategies. They believed that the hands-on and minds-on activities in which they engaged their students had assisted their students in achieving more in chemistry classes. The in-serviced teachers' new approaches to science teaching seemed to concur with the literature on appropriate science teaching methods for middle and secondary schools (Chiapetta & Koballa, 2002).

The teachers implemented small-scale experiments and improvised materials to teach chemistry while focusing on their students' practical experiences. Incorporating students' practical experiences in teaching and learning of chemistry assists the learners to make sense of school science in relation to their environment (Driver, 1995). From the findings, the participants used locally available materials such as plastic containers and polythene papers to improvise equipment to conduct experiments in chemistry. The participants used local processes such as brewing of alcohol to assist their students to make connections between the science they experience outside school and school science. The locally available materials and processes have names in the students' first languages. According to the participants, the students in the rural schools described the local processes using their familiar names before they are introduced, for example, to industrial processes involving the manufacture of alcoholic beverages. The use of local processes, materials and terminologies based on the students ethnic languages, as starting points, to teach chemistry was in line with studies that focus on diversity in science education (Lee & Fradd, 2001; Lemke, 2001; Rodriquez, 1998) and students' "border crossings" in science classes (Aikenhead, 1998). By so doing, the students are assisted to make sense of the school chemistry in relation to their life experiences.

Of particular importance, was the teachers' lesson evaluations (Danielson, 1996) in which the in-service teachers planned and assessed their lessons or used students or colleagues to provide feedback on their lessons. From the observed lessons, teacher reflections and lesson plans collected during the study, it seemed the PDSI approach in lesson implementations assisted the in-service teachers improve on their subsequent lessons. The in-service teachers believed that their new chemistry teaching approaches were beneficial to their students because they now taught the chemical concepts with ease. The findings indicate that the in-service teachers felt that the teaching of the Periodic Table, “mole concept”, electrochemistry, and organic chemistry, which students used to have difficulties in, had become easier to teach and the learners are more involved in student-centered learning activities. These multi-site case findings on the teachers’ practices about the teaching and learning of chemistry following professional development compare well with other studies on teacher beliefs and practices in science teaching (Verjovsky & Waldegg, 2005).

Changes made in designing and implementing lessons following in-service courses. The in-serviced teachers made changes in their lesson plan formats that were teacher-friendly when executing the lessons in classes. Although much thought was put into the lesson plan preparations, it was easy for the teachers to implement the lessons. The teachers changed from having teacher-centered to student-centered lessons. They based their lessons on their learners’ practical experiences and locally available materials. It has been argued that one way that the teaching of chemistry in Kenya can be made meaningful to many rural school students was to incorporate indigenous science education in the curriculum (Thomson, 2003; Thomson, 2002). The teachers’ focus on local processes and materials was a positive move towards making chemistry teaching relevant to the learners in relation to their environment.

In the new approach to the teachers’ chemistry instructions, the findings seem to indicate that the in-service teachers played the roles of guides, facilitators and supervisors during the student learning activities. As Sita put it “let the students do the activities as the teacher sees.” The findings showed that the in-service teachers made changes in their lesson assessments. In addition to self-evaluations, it was evident from the observed lessons and the evaluations sheets collected at the end of the lessons that the in-service teachers involved their students and colleagues in providing feedback on the lessons taught for diagnostic purposes. This was a new development on the Kenyan secondary school teachers' practices following professional development. This change of the in-service teachers' practices in teaching and learning chemistry seemed to have a positive impact on their view about their students in rural district schools. The in-service teachers involved all their students in learning chemistry. This finding augurs well with other scholars' work on how to assist students from different socio-economic and cultural backgrounds to participate fully in science classes (Lee & Fradd, 2001; Lemke, 2001; Rodriquez, 1998).

Considerations in the SMASSE in-service education program. In-service teacher education programs are a viable option, and if well-managed, can facilitate [on-going] professional growth through knowledge exchange related to practical experience in the teaching field (Luft, 2003; Radford, 1998; vanDriel, Beijaard, & Verloop, 2001). Considering evidence from the participants, there were some issues that need to be considered in implementing effective in-service teacher education programs (Garet, Porter, Desimone, Birman, & Yoon, 2001). Although Kenya can be commended for the rapid developments in teacher education it had achieved during its first 40 years of independence, much more was needed to be addressed in order to enhance science teacher education programs nationally.

First, it was observed from the participants that science education personnel with relevant experience and professional qualifications (on science content and pedagogical content knowledge) should handle a professional development program for science teachers. The trend of recruiting national in-service science teacher educators, from a pool of high school teachers and based on job groups regardless of academic and professional advancement, might be counterproductive to the purposes of the program. It was likely that a good number of teachers might have been promoted to higher job groups because of the schools or regions they were teaching in or because of political patronage that became prevalent in the 1980s to the year 2002. Teachers with postgraduate qualifications [Master's and Ph.D.'s] in science education and with considerable experience in science teaching should be recruited to conduct in-service teacher education programs.

The participants believed that an instructor should be more knowledgeable than the learners themselves in any new course to be conducted. Kenya's quality assurance and education standards' officers should be recruited from among experienced teachers based on post-graduate qualifications for the subjects they head or are in-charge of, at the district, provincial or national level. Kenya's rapid education expansion required highly qualified and experienced personnel in key decision-making areas of teacher education programs.

Secondly, the participants argued that different geographical regions with disparity in provision of school science facilities, and students' practical experiences based on sociocultural, economic and political backgrounds require special in-service teacher education programs targeting those specific areas to address learners' "border crossings" (Aikenhead, 1998). Special professional development programs are required for teachers with different academic and professional qualifications such as holders of Diploma in science education (Dip. Sc. Ed.), Bachelor's degree in education (B. Ed.), Bachelor's degree in science (B. Sc.), Master of education degree (M. Ed.), and Master of science degree (M. Sc.), who were likely to have different needs and aspirations. There ought to be courses from which individuals can choose based on their qualification and need to enhance regarding science content and professional content knowledge level. This requires interventions and collaborative efforts with university professors involved in pre- and in-service teacher education (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

From the interviews, it was noted that university science education professors were not directly involved in the SMASSE programs, partly because many of the ministry officials making decisions on in-service teacher education issues did not have qualifications beyond a bachelor's degree. The Kenyan authorities ought to realize that even though people of lower academic qualifications have been in-charge of important government offices since independence, it is high time to have professionals with advanced education degrees administering the in-service teacher education system in Kenya.

Thirdly, participants indicated that the SMASSE in-service science teacher education program emphasized student-based hands-on and minds-on activities through experiments and improvisation (ASEI) Movement. While the ASEI movement appeared to be the main theme in the project, it was also important to consider in-servicing of teachers more on inquiry-based activities and how to assess student progress in such situations (Keys & Bryan, 2001). Students are likely to understand more when given opportunities to explore their conceptual frameworks through experimental and discussion activities (Driver, 1995). This can be achieved, in part, by having teachers in Kenya exposed to writing reflective journals based on their teaching (Bryan, 2003). Teachers' journals can assist in having written cases on how to teach a given science topic at a given level and in a given region in Kenya. An in-service program that only focuses on ASEI lesson planning and implementation was likely to be inadequate, as there are many other aspects of professional development that ought to be addressed in relation to various socio-economic and geographic contexts (Lavoie, & Roth, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Fourthly, Kenya’s in-service science teacher education programs also ought to include other professional development programs such as school-based mentoring and coaching, staff development (Loucks-Horsley, Hewson, Love, & Stiles, 1998), instructional congruence (Lee &

Fradd, 2001), and multicultural science teacher education models (Lavoie & Roth, 2001). In-servicing teachers using one model of in-service teacher education, for instance the cascade in-service model, based on another country's science teacher education models might not be the only solution to Kenya's science education problems other than creating more alienation in the education system. Hands-on and minds-on activity-oriented teaching strategies, as emphasized in the ASEI movement and PDSI approach, ought to include issues of diversity in the science classroom (Lavoie & Roth, 2001). The multi-site cases of teachers seemed to support the assertion that diversity of Kenyan public secondary schools and resources for science teaching/learning had an impact on the teachers' experiences and beliefs about the teaching of chemistry following in-service courses. The use of locally available materials to teach chemistry units was a great idea but not sufficient in addressing diversity in Kenya's science education classrooms.

Fifth, participants felt that there should be follow up activities and all-year round in-service activities for teachers to attend at their convenience in Kenya. One way to address this, as suggested by participants, was by having a science teachers forum (e.g. Science Subject Teachers Associations), in which teachers can exchange views on science teaching and their experiences. These forums can also be one way in which senior science teachers can play an important role in in-service teacher education (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Collaboration between science teachers in schools and teacher education institutions is likely to be fostered through such associations, other than having teacher educators visiting schools to assess student teachers during student teaching sessions only.

It was observed that teacher education supervisors in Kenya hardly have time to talk to members of staff or heads of department or school administration when they visit schools to monitor the progress of the in-serviced teachers. Science teacher education in Kenya can be enhanced through promotion of collaborative efforts between educators and the schools' administration, and encouraging science teacher forums at various levels of the education system.

Implications on Science Teacher Education

The study findings were seen to have implications on three interrelated components: in-service teacher education policy, administration and the stakeholders. The implications are summarized in Figure 8.

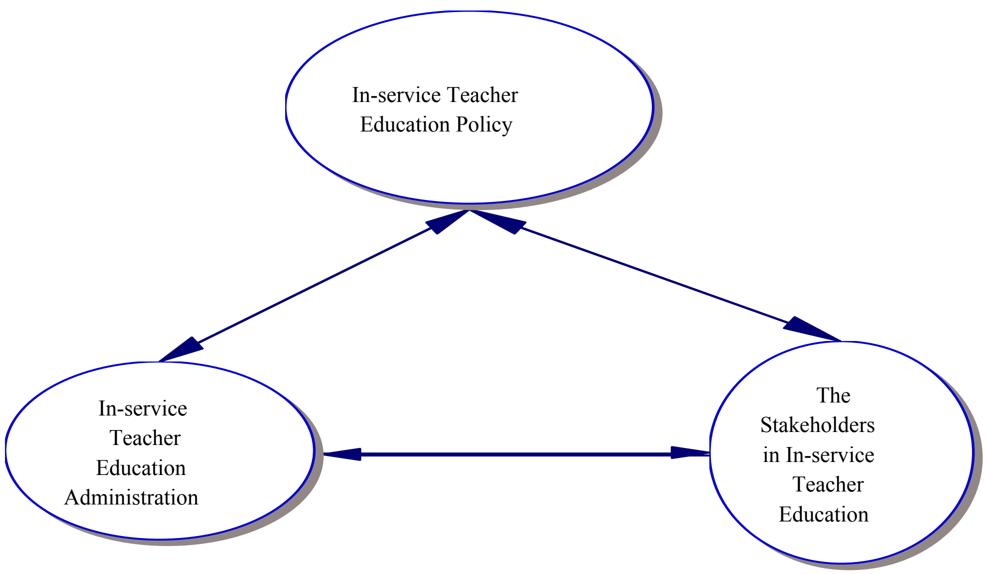


Figure 8. Implications on in-service science teacher education

The study findings were seen to have implications on in-service teacher education policy, the administration of in-service education programs and the in-service education stakeholders (Figure 8) to address the areas that the participants had dissatisfactions in.

Implications for in-service teacher education policy. Professional development of science teachers to enhance school science teaching and learning has become an area of concern to many stakeholders (Loucks-Horsley, Hewson, Love, & Stiles, 1998). It has been argued that the traditional in-service teacher education programs are inadequate in preparing science teachers to effectively implement the national standards of education in science education (NRC, 1996). This calls for new ways of preparing and supporting professional teachers in science education. From the study findings, in-service science teacher education programs in Kenya ought to include other professional development programs such as school-based mentoring and coaching (Danielson, 1996), staff development (Loucks-Horsley, Hewson, Love, & Stiles, 1998), "instructional congruence" (Lee & Fradd, 2001), and multicultural science teacher education models (Lavoie, & Roth, 2001). To continue promoting effective science education instruction and learning environments (Chiapetta, & Koballa, 2002; Sapovitz & Turner, 2000), the study findings seem to suggest that Kenya needs a policy on planning and conducting professional development programs based on local contexts.

In-service science education courses in many less industrialized, non-western countries such as Kenya are modeled on western teacher education systems and implemented with sponsorship from industrialized countries. Although many students from Kenya come to study in the western universities, over reliance on western based science education and textbooks by Kenya does not help many of its students and teachers who are born, go to school and continue to stay within their local communities. It has been argued that in-service teacher education programs in less industrialized, non-western countries ought to include aspects of indigenous science education (Engida, 2002; Thomson, 2003; Thomson, 2002). By so doing, school science teaching and learning in Kenya can be made meaningful and relevant to the recipients who are taught science using English, which is not their first language (Rollnick, 1998).

In-service teacher education programs are a viable option, and if well-managed can facilitate [on-going] professional growth through knowledge exchange related to practical experience in the teaching field (Luft, 2003; Radford, 1998; vanDriel, Beijaard, & Verloop, 2001). It has been argued that a professional development program for science teachers should be handled by science education personnel with relevant experience and professional qualifications (vanDriel, Beijaard, & Verloop, 2001). On the other hand, different geographical regions with disparity in provision of school science facilities, and students' practical experiences based on sociocultural, economic and political backgrounds (Cobern, 1998) require special in-service teacher education programs targeting those specific areas to address learners' "border crossings" (Aikenhead, 1998). Special professional development programs are also required for teachers with different academic and professional qualifications, who are likely to have different needs and aspirations. There ought to be courses from which individuals can choose, based on their qualification and need to upgrade regarding science content and professional content knowledge level. This requires interventions and collaborative efforts involving local communities and university professors handling pre-service and in-service teacher education programs (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

At the time of this study, there are no documents on secondary school teachers' experiences in designing and implementing science lessons following the SMASSE project in-service courses in Kenya. This work is likely to be the first to document the in-serviced secondary school teachers' experiences in Kenya following a national collaborative professional development pilot project program. These study findings are likely to assist the education development partners, from industrialized countries, focusing on East Africa, in particular

Kenya, in planning, organizing and implementing pre- and in-service science teacher education programs.

The development partners ought to work from and with the communities they assist and not to impose their in-service models on the consumers who might not be ready for it or might find it inadequate in meeting their local needs. Having the counterpart personnel earning colossal amounts of money in form of salaries and allowances, while the local counterparts and the in-service participants were languishing in poverty hindered the recipients' effectiveness, efficiency, impact, sustainability, monitoring and evaluation of the project activities. It was assumed that the teachers needed no compensation because they were on duty and on their employer's pay roll, but the multi-site cases indicated that the participants were dissatisfied with the in-service education policies and administration. Although the participants had improved their teaching and improvisation skills during the in-service sessions, they had not been compensated in any way by either the in-service education providers or the employer. There was need to have a policy to address the plight of teachers who were serving as in-service educators. Their workloads in schools ought to be reduced by having more teachers deployed to their stations and if possible have them serve as full time in-service educators in their districts.

An in-service education programs' policy was required to address the needs of in-serviced teachers in schools. The in-service education programs ought to be all-year round activities for teachers. This means that a policy ought to be put in place to have personnel to administer the in-service education at the district levels throughout the year. An organization structure ought to be drawn and ensure that there were enough qualified personnel to implement the in-service education activities in the districts. Monitoring and evaluation of the in-service education activities in the districts ought to be strengthened, as this was the area that the participants were most dissatisfied with. Frequent transfer of personnel involved in the implementation of the in-service education programs to other districts hampered a given district's efforts to effectively in-service her teaching force. A policy was, therefore, required to ensure that the in-serviced teachers remained in the district for at least three years for the district to benefit from their investment in in-servicing its teaching force. It seemed the pilot districts spent colossal amounts of money to educate their science teaching force only to have them frequently transferred to other districts by the Teachers Service Commission.

Implications for in-service teacher education administration structure. It was hoped that this study will assist the teacher education planners in developing and implementing appropriate national in-service science teacher education curricula that address the constraints schools and science teachers face as a result of the disparity in the provision of science education resources in the diverse regions of Kenya. The planners ought to consider teacher motivation seriously during the organization and implementation of in-service teacher education programs. Any teacher undergoing an in-service course ought to be recognized, among others, through accumulation of staff development units and payment of participation allowance. The professional development courses for teachers ought to lead to a teacher's higher professional qualifications. This was not the case in the SMASSE in-service education programs.

In collaboration with science teacher education institutions, the Kenya National Examinations Council (KNEC) and the Kenya Institute of Education (KIE) ought to be the main bodies to design and implement the in-service education programs. These bodies prepare the national examinations and science curriculum for public schools, respectively. From the multi-site case studies, it was noted that the national examinations and school science curricula influenced the teachers' approach to science teaching. Unless the SMASSE project had the

KNEC and KIE participating in the in-service education programs as equal partners, the success of having teachers employ the ASEI movement and PDSI approach in their chemistry unit designs and implementation was likely not to be sustained. The teachers were likely to continue preparing their students for the national examinations following the format of the examinations' questions. This left no room for student investigations and improvisation of science teaching/learning materials.

Secondary school science teachers ought to be in-serviced along with other teachers in other subject areas. The students need to master English language in order for them to be able to communicate well. They need to know more about their local communities in order for them to be able to relate school science with what is found outside school. This calls for collaborate efforts in all areas of teacher education for the benefit of the students. The in-service teacher education at secondary school level ought to have a link to that of science teachers at primary school level. It is the primary school science teachers who prepare children for secondary school thus a need to have the in-service at both levels having similar objectives and a forum to exchange ideas to improve chemistry teaching and learning in schools. In this regard, there was need to transform the Kenya National Union of Teachers (KNUT) from being a trade union organization to more of a professional body. Over the years the KNUT has been fighting for teachers' salaries and promotions with hardly any reference to or involvement in the professional development of teachers in the public schools. This was an area that the SMASSE project never addressed. An all-year round in-service education administration structure was required at all levels, especially at the district level where the majority of the stakeholders were found. There was need to have fulltime qualified in-service education administrators at the district in-service education centers and/or offices.

Implications for in-service teacher education stakeholders. From the findings, the SMASSE project cascade in-service education design appeared to be incorporating some aspects of staff development and collaborative models. In collaboration with the District Education Boards (DEBs), the headteachers' associations and parents' associations made contributions, administered and implemented the SMASSE in-service education programs in their respective districts. However, it appeared that the SMASSE Project planners had a top down administration structure which did not augur well with many of the stakeholders in the districts. There was need to have a bottom up or horizontal in-service education administration structure in which the teachers, parents, teacher education institutions, District Education Boards, head teachers' association, Kenya National Union of Teachers were more involved in the in-servicing of teachers in their local districts. The national in-service education team ought to play an advisory role than being the planners, implementers, administrators, project evaluators and the judges for the project activities that needed more of local than national interventions. In many occasions, the local in-service education stakeholders appeared not to be treated as equal partners in the project activities. They had to be told what to do by the national team whose contributions were mainly on the establishment of the district in-service resource centers and in-servicing of the district in-service educators. Successful in-service education programs were likely to be among those that empowered all the stakeholders in education (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Implications for further research. There is need to have further research to find out whether the students taught by the SMASSE in-service teachers had an advantage over their counterparts taught by those who do not attend SMASSE organized in-service teacher education programs. This study only focused on teachers' practices and experiences in chemistry unit lesson planning and implementation following their in-service courses as in-service educators, heads of department and practicing teachers. There is also need to find out whether the SMASSE in-serviced teachers planned and implemented their chemistry lessons differently from those who did not attend the in-service teacher education programs.

This study documented the in-service teachers' satisfiers and dissatisfiers in relation to their practices in chemistry classrooms. It is assumed that minimizing the dissatisfiers will motivate teachers to participate in the in-service activities and implement effective classroom practices. Further research is needed to establish whether students taught by teachers with minimum dissatisfiers have high achievement in chemistry.

The findings seem to indicate that teaching chemistry using improvised materials in rural district schools enhanced students' participation in chemistry learning. However, further research is needed to establish the extent to which improvisation in chemistry enhanced district school students' achievement in chemistry in relation to the national chemistry examinations in Kenya. From the study findings, there was need to in-service school principals and laboratory assistants in Kenya on how to administer chemistry curriculum. Additional research is also required to find out whether in-servicing school principals on how to implement chemistry curricula leads to improved chemistry in-service teachers' classroom practices and student achievement in their schools.

So what? The implications are likely to inform the in-service education curriculum and assessment planners on the satisfiers and dissatisfiers in-service teachers experience when attending professional development courses and when implementing science curricula in schools. The methodology and findings of this study suggest that project evaluations that involve qualitative methods generate extra reliable and credible information about in-service teachers which may not be possible when the quantitative methods are used. Based on the numbers of in-service teachers and analysis of the questionnaires the participants responded to, the SMASSE project evaluations indicated that the in-servicing of teachers was successfully implemented in all the pilot districts. However, this study suggests otherwise. The study implications seem to indicate that the SMASSE project teaching approaches are viable ways of teaching science in schools with inadequate provision of science facilities. The implications of the study also suggest that teacher reflections are powerful tools to study teachers' classroom practices following professional development programs.

The development partners in education (Donors), in collaboration with the recipient governments in less "industrialized" countries such as Kenya, ought to involve the local communities or stakeholders more in the decision making processes in the in-service programs. The top down model of implementing projects seems to alienate the voices of the local people who are supposed to be the beneficiary of such projects. Perhaps bottom-up or horizontal models in decision making will make the stakeholders to experience their ownership of professional development projects at the local levels.

Conclusions

Teaching of the periodic table was viewed as the core of chemistry education. When appropriate teaching approaches are used, students are able to better understand the trends and patterns in the periodic table. Thorough student preparation on valences and writing chemical formulae of compounds was a prerequisite to students' ability to balance chemical equations.

The "mole concept" was one of the topics that high students had most apprehensions. However through SMASSE in-service teacher education programs, the teachers were able to organize relevant activities based on students' every day experiences to enhance their understanding of the topic. Students should be given more practice in calculating "mole" related problems before they start titration experiments.

In electrochemistry students should understand the difference between electrolytic and voltaic cells, as they get involved in activities that involve movement of ions. In organic chemistry teachers ought to use organic materials that students come across in their environment in order to draw the attention of students.

Kenya has made tremendous progress in science teacher education since independence. Careful thought needs to go into the planning and implementing of pre-service but more so in in-service teacher education programs if Kenya is to advance and maintain a highly skilled teaching force. The in-service programs should be planned to meet the teachers' expectations in terms of teaching methods and recognition of the in-serviced teachers by their employer.

University professors should also play a more central role in all areas of in-service science teacher education programs. University professors prepare pre-service teachers, have relevant and advanced educational research skills and are likely to make informed choices based on the theories they generate through research and how the theories can be incorporated into educational practice. I believe that there is no practice without a theory behind it nor can a theory be useful if it cannot be put into practice. The in-service science teacher education programs in Kenya can therefore be strengthened if more university science education professors are involved in them. It is through such involvement that Kenya’s university science education professors can see the need to plan and incorporate science education courses that target school science teachers in their university programs. These courses ought to have credits that add to the teachers' staff development units that the SMASSE in-service programs did not address. These in-service teacher education programs ought to target also heads of science departments in schools and the head teachers on how to administer and finance school science activities. In this regard, the stakeholders in school science education play a major role and ought to collaborate in strengthening the teaching and learning of school science through in-service teacher education.

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APPENDICES

Appendix A

Consent Form

I, _________________ , agree to take part in the research study, titled Secondary School Teachers' Experiences in Designing and Implementing Chemistry Lessons Following In-service "training" Courses: A Case of Kenya, which is being conducted by Justus Inyega, Science Education Department, The University of Georgia, U.S.A., 1-706-542-2108, 254-2-561406 under the direction of Dr. Norman Thomson, Science Education Department, The University of Georgia, 212 Aderhold Hall, Athens, GA 30602-7126, U.S.A., 1-706-542-4642.

I do not have to take part in this study; I can stop taking part at any time without giving any reason, and without penalty. I can ask to have all the information returned to me, removed from the research records and destroyed.

The purpose of this case study is to investigate the chemistry teachers' experiences in:

- Designing chemistry lessons following the National (SMASSE) In-service Professional Development Programs in Kenya
- Implementing chemistry lessons following the National (SMASSE) In-service Professional Development Programs in Kenya
- Making changes when designing and implementing chemistry lessons plans following the National (SMASSE) In-service Teacher "training" Programs in Kenya.

I understand that I will not benefit directly from this research. However, my participation in this research may lead to information that could help enhance the existing pre-service and in-service teacher education programs.

My part in this study will last through the months of January to December 2004.
If I volunteer to take part in this study, I will be asked to do the following things:

- Permit the researcher to observe about two of my chemistry classes and let him take field notes when I am teaching. Each observation will last approximately 1 hour depending on the lesson duration
- Write reflective journals on my observed lessons
- Permit the researcher to go through my reflective journals when it is submitted.
- Permit the researcher to write a reflective journal based on our conversations on my ideas about designing and implementing chemistry unit lessons on chemistry teaching.
- Permit the researcher to interview me before and after observing me teaching in class
- Participate in two audio taped (pre-observation and post-observation) interviews of approximately an hour each
- Permit the researcher to audiotape the interviews

- Participate in the focus group procedure lasting about one hour, and allow the researcher to audiotape the focus group interview
- Permit the researcher to review and collect copies of any of my chemistry lesson plans, schemes of work, teacher's lesson notes, syllabus and list of class textbooks
- Be allowed to review tapes of my interviews and transcripts of those tapes.

The researcher has informed me that there are no discomforts or stresses expected nor are there any anticipated risks due to my participation in this study. I understand that all information collected during this study, including the name of my school or department, will be treated confidentially (unless required by law), and only pseudonyms will be used in the final project.

I also understand that audio and copies of transcripts will be kept until December 2007 by the researcher for research and educational purposes. There is a possibility that audio tapes with voice could be used in either teaching or conference presentations. This is subject to my permission below.

Audio tapes with my voice may be played at meetings of researchers.

Yes______ No________
[Please Initial]
Audio tapes with my voice may be played in classrooms to students.

Yes_______ No_________
[Please Initial]

I understand that the audio tapes will be stored in a locked cabinet and will be destroyed in December 2007 (i.e. at the end of three years after completion of the research study).

I am also aware that the researcher will answer any further questions about the research project, now or during the course of the project and can be reached by telephone at: 1-706-542-2108 (The University of Georgia, USA) or 254-2-561406 (The Kenya Science Teachers' College, Nairobi-Kenya).

My signature below indicates that the researcher has answered all my questions to my satisfaction and that I consent to volunteer for this study. I have also been given a copy of this form.

____
Signature of participant and Date

____
Signature of researcher and Date
(1-706-542-2108, 254-2-561406; email: jinyega@coe.uga.edu)

For questions or problems about your rights please call or write: Chris A. Joseph, Ph.D., Human Subjects Office, University of Georgia, 606A Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411, U.S.A; Telephone (1-706) 542-3199; E-Mail Address IRB@uga.edu

Appendix B

Semi Structured Interview Guide

1. Tell me about your teaching background. (Probes) When, where, etc.
2. Tell me what prompted you to become a chemistry teacher
3. How did you come to participate in the SMASSE Project In-service Program? How were you educated to become a chemistry teacher? Describe that education. Describe your chemistry teaching before the SMASSE Project? (Probes) content, instructional methods, etc.
4. What were the major benefits you received from the SMASSE Project In-service Program? What did you learn that you did not already know?
5. How has the SMASSE In-service Program influenced your design of the chemistry unit lesson plans?
6. What changes have you made in the design of subsequent chemistry unit lesson plans? (Probes)Why have you made them? What has influenced you here?
7. How has the SMASSE In-service Program influenced your implementation of chemistry unit lessons involving the "mole concept", electrochemistry, organic chemistry, and the periodic table?
8. What changes have you made in the implementation of your subsequent chemistry unit lessons? (Probes)Why?
9. How do you implement the changes that you make in your chemistry unit lesson plans during instruction?
10. What should the SMASSE Project planners know and do for future chemistry teacher in-service?

Appendix C

Reflective Journal

I am requesting you to write a reflective journal about your ideas on designing and implementing chemistry unit lesson plans during the months of January and February 2004. Your reflections should focus on:

1. How you went about planning for teaching of the lesson, the activities that were to be a part of the lesson, the resources needed for the lesson, and the assessment of how well you taught the lesson.
2. What changes you made during the teaching of the lesson, and
3. What things would you change as a result of teaching the lesson on the following topics
    a) The periodic table
    b) The "mole concept"
    c) Electrochemistry
    d) Organic chemistry
    e) (Or) any other chemistry topic in your schemes of work for first term, 2004.

Appendix D

Semi Structured Focus Group Interview Guide

1. How did you come to participate in the SMASSE Project In-service "training" program?
2. What were your major benefits from the SMASSE Project In-service "training" program? What did you learn that you did not already know?
3. How has the SMASSE In-service "training" program influenced your design of the chemistry unit lesson plans?
4. What changes have you made in the design of subsequent chemistry unit lesson plans? (Probes)Why have you made them? What has influenced you here?
5. How has the SMASSE In-service "training" program influenced your implementation of chemistry unit lessons?
6. What changes have you made in the implementation of your subsequent chemistry unit lessons? (Probes)Why?
7. How do you implement the changes that you make in your chemistry unit lesson plans during instruction?
8. What should the SMASSE Project planners know and do for future chemistry teacher in-service?

Appendix E

DATA COLLECTION LOG

<table>
<tr><th>DATE</th><th>SIMBA DISTRICT</th><th>CHUI DISTRICT</th></tr>
<tr><td colspan="3">1/15/2004
• Visited KSTC/SMASSE Project In-service Education Unit in Nairobi, Kenya
1/16
• Processed research permit from the Ministry of Education, Science and Technology, Kenya
1/19
• Discussion with the Head, SMASSE In-service Education Unit in Nairobi, Kenya
1/20
• Left Nairobi for Simba and Chui Districts for data collection</td></tr>
<tr><td>1/21/2004</td><td>• Visited Moja, Mbili and Tano in their schools</td><td></td></tr>
<tr><td>1/22</td><td>• Interviewed Moja
• Visited Tatu</td><td>• Visited Tisa</td></tr>
<tr><td>1/23</td><td>• Interviewed Mbili
• Visited Tatu</td><td></td></tr>
<tr><td>1/24</td><td>• Interviewed Tatu</td><td>• Interviewed Tisa</td></tr>
<tr><td>1/25</td><td colspan="2">• At my residence. Listened to the interviews I had audio taped</td></tr>
<tr><td>1/26</td><td>• Observed lessons and had lesson reflections from Tatu</td><td>• Visited Nane</td></tr>
<tr><td>1/27</td><td>• Observed lesson and had lesson reflections from Mbili</td><td>• Observed lesson and had lesson reflections from Nane</td></tr>
<tr><td>1/28</td><td>• Interviewed Nne</td><td>• Interviewed Nane</td></tr>
<tr><td>1/29</td><td></td><td>• Observed lesson and had lesson reflections from Nane
• Interviewed Sita</td></tr>
</table>

1/30	• Observed lesson and had lesson reflections from Tatu • Observed lesson and had lesson reflections from Mbili • Observed lesson and had lesson reflections from Moja	
1/31	• Informal discussions with Moja and Tatu in Simba town	
2/01	• At my residence checking on the field notes and listening to the audiotapes	
2/02	-Participants were not teaching (Reporting day for Grade 9 students)	- Participants were not teaching (Reporting day for Grade 9 students)
2/03	• Observed lesson and had lesson reflections from Tano • Observed lesson and had lesson reflections from Mbili	
2/04	• Observed lesson and had lesson reflections from Nne • Observed lesson and had lesson reflections from Moja	
2/05	• Observed lesson in two consecutive classes and had lesson reflections from Tano	• Observed lessons and had lesson reflections from Tisa (two different classes)
2/06	• Observed lesson and had lesson reflections from Tano	• Observed lessons and had lesson reflections from Sita
2/07	• At my place of residence checking on the field notes and listening to the audiotapes	
2/08	• At my place of residence checking on the field notes and listening to the audiotapes	
2/09	• Interviewed Tano	• Observed lesson and had lesson reflections from Kumi
2/10	• Observed lessons and had lesson reflections from Moja • Observed lesson and had lesson reflections from Tatu	

2/11	• Observed lesson and had lesson reflections from Nne	• Interviewed Saba • Lesson observation and reflection from Nane
2/12	• Observed lesson and had lesson reflections from Moja	• Interviewed Nane
2/13	• Observed lesson and had lesson reflections from Tano	Observed lesson and had lesson reflections from Nane
2/14	• At my residence checking on the field notes and listened to some audiotapes on the lessons observed	
2/15	• Focus group interview (Moja, Mbili and Tatu)	
2/16		• Observed lesson and had lesson reflections from Nane • Observed lesson and had lesson reflections from Kumi
2/17	• Observed lesson and had lesson reflections from Mbili	• Observed lesson and had lesson reflections from Tisa
2/18	• Observed lesson and had lesson reflections from Moja	• Focus group interview (Sita, Saba and Nane)
2/19		• Observed lesson and had lesson reflections from Saba
2/20	• Observed lesson and had lesson reflections from Tatu • Observed lesson and had lesson reflections from Tano • Observed lesson and had lesson reflections from Moja (in the evening)	
2/21	Left for Nairobi from the field	