May 2014

Describing students' talk about physical science phenomena outside and inside the classroom: A case of secondary school students from Maragoli, Western region of Kenya

Grace Nyandiwa Orado
Syracuse University

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Abstract

Because of cultural and linguistic influences on science learning involving students from diverse cultural and linguistic backgrounds, calls have been made for teachers to enact teaching that is sensitive to these students’ backgrounds. However, most of the research involving such students has tended to focus on students at elementary grade levels from predominantly two linguistic backgrounds, Hispanic and Haitian Creole, learning science concepts mainly in the life sciences. Also, most of the studies examined classroom interactions between teachers and the students and among students. Not much attention had been paid to how students talk about ideas inherent in scientific phenomena in an outside-the-classroom context and much less on how that talk relates to that of the classroom. Thus, this research extends knowledge in the area of science learning involving students learning science in a language other than their first language to include students from a language background other than Hispanic and Haitian Creole at not only the high school level but also their learning of ideas in a content area other than the life science (i.e., the physical sciences). More importantly, this research extends knowledge in the area by relating science learning outside and inside the classroom.

This dissertation describes this exploratory research project that adopted a case study strategy. The research involved seven Form Two (tenth grade) students (three boys and four girls) from one public, mixed gender day secondary school in rural Kenya. I collected data from the students through focus group discussions as they engaged in talking about ideas inherent in selected physical science phenomena and activities they encountered in their everyday lives, as well as learned about in their science classrooms. I supplemented these data with data from one-on-one semi-structured interviews with two teachers (one for chemistry and one for physics) on their teaching of ideas investigated in this research, the secondary school syllabus (KIE, 2002) as
well as the students’ responses to questions on teacher-made assessments involving the ideas investigated.

Three main findings emerged through this research. The findings are: (1) the students adopted everyday ways of making sense of the world (i.e., everyday language and everyday observations) in talking about ideas investigated both outside- and inside-the-classroom contexts, (2) cultural knowledge emerged from the student’s talk related to the nature and form of lightning different from that emphasized in science, and (3) students who may initially seem uninterested in participating in discussions involving science ideas showed possibilities for participation in such discussions. Drawing on the work of scholars such as Aikenhead (2001), Ballenger (1997), Brock-Utne (2007), Herbel-Eisenmann (2002) and Warren et al. (2001), I argue that students’ everyday ways of making sense of the world are rich starting points from which to leverage students towards meaningful learning in science. However, this may happen only if instructional materials such as the syllabus are explicit in not only giving examples of phenomena and students’ experiences with them in outside the classroom contexts, but also acknowledging that possibilities exist for cultural understanding and talk about ideas inherent in the phenomena involving ideas students learn about in their science classrooms.
DESCRIBING STUDENTS’ TALK ABOUT PHYSICAL SCIENCE PHENOMENA OUTSIDE AND INSIDE THE CLASSROOM: A CASE OF SECONDARY SCHOOL STUDENTS FROM MARAGOLI, WESTERN REGION OF KENYA

By

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M.ED. (Science Education) Kenyatta University, 2009

DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Science Education in the Graduate School of Syracuse University

May 2014
Dedication

To my mother, the late Deborah Abulwa. Through the first language you gave me I came to the understanding of how the world works. Little did I know that the same language would become a tool to help me reflect upon ideas in science as I compared how the same ideas are viewed through English, the language of instruction in Kenya. It is this reflection that formed the basis for this project. RIP mama.
Acknowledgements

There are people I definitely want to thank for their contribution in making this work become a reality. First and foremost I would like to thank my dissertation committee led by Dr. Jeffrey Rozelle for their support and working with me not only during the dissertation process but also for periods dating back from the time I joined the doctoral program when I took classes with each one of them. I believe that it is through courses I took with them that the idea behind this dissertation started to form in my mind. Specifically I thank Dr. Rozelle for his role as the director of my dissertation and advisor throughout my doctoral program. He was available for consultation from the time this dissertation was still a mere idea in my mind. I did not have to set appointments to talk to him. Although he left Syracuse University mid-way through my program to join work assignments elsewhere, at no one time did I feel that I lacked someone to guide me in this process. He made himself available through technology tools such as emails, hangouts and telephone, and worked tirelessly in providing feedback on all the drafts of the work I gave him starting with the proposal through the several drafts of the individual chapters of the dissertation to the several drafts of the dissertation itself. His feedback was invaluable and helped in steering me in the direction that saw me completing this work in a timely manner. I cherish his superb commitment to the success of my project.

I also feel indebted to Dr. Sharon Dotger and Dr. Joanna Masingila both who served as members of my dissertation committee for the crucial role they played in providing feedback on my work right from the proposal to the dissertation that saw me improve the quality of this dissertation. Specifically I thank Dr. Dotger for her time and role in pushing a notch higher, my understanding of some of the ideas investigated in this research, especially those related to the physics content. Just like Dr. Rozelle, I consulted her whenever I wanted and in most cases I did
not have to set appointments before seeing her. On the other hand, I was humbled but at the same time thankful for Dr. Masingila’s attention to detail with regard to my written work. Through her thoroughness, my dissertation got the professional look it now has.

I am also grateful to the professors I took classes with when I joined the graduate program. They include Dr. Tillotson, Dr. Roy-Campbell, Dr. Smith, Dr. DeVault, Dr. Rodriguez, Dr. Sapon-Shavin, Dr. Bellini, Dr. Foley, and Dr. Lopez. The classes I took with them were incredible and contributed immensely towards my understanding of the different issues as they pertain to education and educational research. To the readers of my dissertation Dr. Roy-Campbell and Dr. Foley and the entire dissertation defense committee chaired by Dr. Chisholm, I am grateful for their feedback that further improved the quality of this dissertation. I also thank Cindy Daley, the office administrator of the department of science teaching for her support and encouragement throughout my doctoral program. Apart from always putting a smile on my face, she handled all the paper work that went into ensuring that my file with students’ academic services was up to date. To all the doctoral students in science education I say thank you for the warm companionship and comradeship we shared. My trip back to Kenya for data collection was supported by funds from the department of science teaching and Women in Science and Engineering – Syracuse University chapter. I am therefore truly grateful for the kind gesture.

Back home in Kenya, I am indebted to the principal of the school where I conducted this research, and the teachers together with the students who participated in this research. For reasons related to ethics in research I cannot refer to them by name but I remain indebted to them for allowing me to conduct this research in their school and giving me the opportunity to peek into their ideas. It contributed immensely to the realization of this project. To Josphat Anaye, I am grateful for helping me make sense of my data though translations and interpretations of
some of the students’ talk done in Kiswahili. I am also grateful to the Teachers’ Service Commission, my employer for granting me study leave with pay. This enabled me to meet my financial obligations back home such as payment of school fees for my children. Last but not least I thank my family comprising of immediate family, daughters Thalma and Phylis and my siblings for their encouragement and prayers. Thalma and Phylis thank you for constantly reminding me of our family’s motto, “giving up is not an option.” It steered me closer to the conclusion of this journey of several thousand miles that began with one step.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOG</td>
<td>Board of Governors</td>
</tr>
<tr>
<td>CC</td>
<td>County Commissioner</td>
</tr>
<tr>
<td>DC</td>
<td>District Commissioner</td>
</tr>
<tr>
<td>DEO</td>
<td>District Education Officer</td>
</tr>
<tr>
<td>DQASO</td>
<td>District Quality Assurance and Standards Officer</td>
</tr>
<tr>
<td>GoK</td>
<td>Government of Kenya</td>
</tr>
<tr>
<td>INSET</td>
<td>In-Service Education and Training</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
</tr>
<tr>
<td>KANU</td>
<td>Kenya African National Union</td>
</tr>
<tr>
<td>KCPE</td>
<td>Kenya Certificate of Primary Education</td>
</tr>
<tr>
<td>KCSE</td>
<td>Kenya Certificate of Secondary Education</td>
</tr>
<tr>
<td>KICD</td>
<td>Kenya Institute of Curriculum Development</td>
</tr>
<tr>
<td>KIE</td>
<td>Kenya Institute of Education</td>
</tr>
<tr>
<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
</tr>
<tr>
<td>MoE</td>
<td>Ministry of Education</td>
</tr>
<tr>
<td>NCST</td>
<td>National Council for Science and Technology</td>
</tr>
<tr>
<td>PD</td>
<td>Professional Development</td>
</tr>
<tr>
<td>SMASSE</td>
<td>Strengthening Mathematics and Science in Secondary Education</td>
</tr>
<tr>
<td>TM</td>
<td>Trademark</td>
</tr>
<tr>
<td>TSC</td>
<td>Teachers Service Commission</td>
</tr>
</tbody>
</table>
Chapter One – Introduction

Introduction and Background to the Research

Cultural and linguistic influences on students’ science learning for students from diverse cultural and linguistic backgrounds have been documented (Akpanglo-Nartey, Asabere-Ameyaw, Sefa Dei, & Taale, 2012; Jegede & Okekubola, 1991; Luykx, Lee, Mahotiere, Lester, & Hart, 2007; Westby, Dezale, Fradd, & Lee, 1999). Furthermore, research on science learning involving these students, shows that they experience challenges related to not only the content and language of science but also the language of instruction being different from the students’ first language (Blake & Van Sickle, 2001; Brock-Utne, 2007; Duran, Dugan, & Weffer, 1998; Luykx, Lee, & Edwards, 2008). For these reasons, scholars working with students from diverse cultural and linguistic backgrounds recommend that teachers pay attention to the students’ backgrounds if science learning is to be meaningful and relevant for them (Fradd & Lee, 1999; Fradd, Lee, Sutman, & Saxton, 2001; Lee, 2004). Indeed, research shows that students’ everyday ways of making sense of the world and their first language are tools for meaningful engagement and participation in science learning (Ballenger, 1997; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

While it may be important for teachers to pay attention to students’ cultural and linguistic backgrounds to leverage their learning in science, it is equally important that the teachers are not only aware of understandings and talk about scientific phenomena from outside the classroom students bring to science classrooms, but also have pedagogical skills to enable them to enact that kind of teaching. Most of the research on science learning involving students from diverse backgrounds has been conducted with students from predominantly two linguistic backgrounds
(i.e., Hispanic and Haitian Creole) (Ballenger, 1997; Ciechanowski, 2009; Duran et al., 1998; Luykx et al., 2008; Luykx et al., 2007; Moje, Collazo, Carrillo, & Marx, 2001; Warren et al., 2001; Westby et al., 1999). The students involved were mainly from the elementary school level, learning science concepts mainly in the life sciences (biological sciences). Furthermore, the focus in most of these studies was on classroom communication patterns between the teacher and the students and among students. Not much research has been conducted that focuses on students’ understanding of scientific ideas in an outside the classroom context and much less on how that relates to their understanding of the same ideas from inside the classroom. The limited research available for the outside the classroom context was on cultural knowledge for some communities and how it can be integrated with school science (Aikenhead, 2001; Kawagley, Norris-Tull, & Norris-Tull, 1998; Ng'asike, 2011).

Thus, this dissertation describes a research study through which I sought to examine how secondary school students from the Maragoli community1 of Western region in Kenya understood ideas inherent in selected physical science phenomena both outside- and inside-the-classroom contexts through their talk. The research extends knowledge in the area of students’ learning science in a language other than their first language at a grade level other than elementary, and science ideas in a science discipline other than life sciences. Most importantly, this research extends knowledge in the field by relating science learning outside-the-classroom contexts to that which occurs inside the classroom. This way, it becomes clear what ideas students bring to the science classroom from outside-the-classroom contexts, to which the teachers can draw upon and or build new learning.

---

1 This is one of the communities in Western region in Kenya. People from this community speak Kimaragoli, which is one of the 18 dialects of the Kiluhya language, the dominant language in the region.
This dissertation consists of six chapters, the first of which is this chapter. In this chapter, I provide the introduction of this research that includes the background to the research and background information on Kenya and the education system. It also includes the statement of the problem, purpose of the research and its significance. The chapter ends with a discussion of the theoretical framework that guided this research. In Chapter Two, I present the reviewed literature. I reviewed three main bodies of literature, namely cultural knowledge and science learning, science learning and language, and teaching science to students learning in a language other than the first language. In Chapter Three, I describe the methods I adopted for this research, which include the research design, selection of the research location, setting and participants, data collection and data analysis procedures. In Chapters Four and Five, I describe the findings of this research while in Chapter Six, I present the discussion of the findings in addition to the implications of the findings in science teaching and learning science. I also provide a conclusion of this research in addition to suggesting areas for further research in the same chapter.

In the following section, I provide a brief background on Kenya and the education system. But first, I clarify two terms I have used throughout this dissertation. The first one concerns the label for students from diverse cultural and linguistic backgrounds. These students are recognized in literature in the United States as English Language Learners (ELLs). While it may be true that the students who participated in this research and other students in Kenya are learning English, this label is problematic because it is not reflective of the fact that these students are also learning content in school subjects in English, which is a language other than their first language. For this reason and for purposes of this research I adopted the term Students Learning Science in a Second Language (SLSL2) to refer to this group of students. L2 is a
notation I borrowed from Shatz and Wilkinson (2010) who used L1 and L2 to represent first and second language, respectively, in discussing how L1 supports the learning of L2. The label SLSL2 helps to emphasize the idea that these students are not just learning English but are also learning science in a language other than their first language.

The second term concerns a clarification of the idea of languages in Kenya. Kenya is highly diverse as far as language goes. The general population consists of approximately 40 indigenous communities or tribes with each community having its own culture and language. The indigenous languages are variously referred to as mother tongue or vernacular. Each individual language assumes the name of the tribe prefixed by a “ki” for most of them. For example, people from the Meru, Luhya, and Kalenjin tribes speak Kimeru, Kiluhya and Kikalaljin, respectively. For other communities, the “ki” prefix does not apply; for example, people from the Luo tribe speak Dholuo. For purposes of this research and for the sake of simplicity and uniformity, I refer to these languages as community languages unless I am making reference to a language from a specific community in which case I will use the tribe’s name and prefix it appropriately.

Background Information on Kenya and the Education System

In this section I provide a brief background on Kenya that includes its position on the map of Africa, area occupied, population and administrative boundaries. I also provide the education system that includes the system’s name, schools’ categorization and classification, the secondary school science curriculum, and the language of instruction.

Kenya’s position on the map of Africa. Kenya is an independent country, having gained independence from the British colonial government in 1963. It is one of the countries in East Africa and shares borders with other countries (i.e., Uganda to the west, Tanzania to the
southwest, Sudan to the northwest, Ethiopia to the north, Somalia to the east) and the Indian Ocean to the southeast. It occupies an area of 582,646 square kilometers (224,960 square miles) and has a population of approximately 40 million people (KNBS, n.d.) with 78% of them living in rural areas\(^2\) (UNESCO, n.d.). The equator almost divides the country into two equal parts. Administratively, Kenya is divided into eight regions (formerly provinces) comprising 47 counties. For the map of Kenya showing the regions, see Appendix A.

**Kenya’s education system.** The education system in Kenya is referred to as “8-4-4,” meaning eight years of primary or elementary education, four years of secondary or high school education and four years of tertiary or university education. Except for primary level, entry to other levels is determined through national examinations; students take the Kenya Certificate of Primary Education (KCPE) and Kenya Certificate of Secondary Education (KCSE) examinations, which are used as criteria for selection to join secondary school and university levels, respectively. While it is stated that education both at primary and secondary levels is free, the type of school (see the following school categorization and classification) a student attends determines whether or not parents pay either part or full cost of education. In other words, education is not completely free.

**Schools’ categorization and classification.** Schools in Kenya are categorized either as private or public. Private schools are schools owned by individuals or corporate organizations and therefore parents meet the full cost of education in these schools. The Ministry of Education (MoE) has no control over the kind of curriculum emphasized in these schools. On the other hand, public schools are schools that receive support from the government such as provision of tuition materials, deployment of teachers and payment of teacher’s salaries but parents pay

\(^2\) These are areas where the residents rely on small scale subsistence farming as their main source of livelihood. In some of the rural areas, the residents do not have access to electricity, piped water and communication networks such as good roads
development fees and boarding fees if the school is a boarding school or lunch money if the school is a day school (see school classification that follows). Also the MoE has control over the curriculum that is emphasized in these schools. Within the public and private categories, schools are classified as boarding (i.e., schools where students reside within the school), day (i.e., schools where students commute to school every day) or boarding and day (i.e., schools where some students are accommodated within the school while others commute to school). Secondary schools in the public category are further classified as national (i.e., schools that admit students from across the country. They are given first priority in selecting students based on their performance in KCPE and therefore the top students in KCPE are selected to join these schools), regional (i.e., schools that admit students from the region in which they are located and are given second preference in selection of students based on performance in KCPE), or county (i.e., schools that admit students from the County in which they are located and select students after national and regional schools). The national schools have the highest status compared to regional and county schools. There is yet another classification of all schools based on students’ gender (i.e., boys only, girls only and mixed gender schools). Tables 1, 2 and 3 summarize the statistics on secondary schools categorization and classification based on 2012 data from the Ministry of Education (MoE).

Table 1: Students’ enrollment in secondary schools by school category

<table>
<thead>
<tr>
<th>School category</th>
<th>Number</th>
<th>% of total</th>
<th>Enrolment</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>6,188</td>
<td>75.49%</td>
<td>1,704,512</td>
<td>89.48%</td>
</tr>
<tr>
<td>Private</td>
<td>2,009</td>
<td>24.51%</td>
<td>200,311</td>
<td>10.52%</td>
</tr>
<tr>
<td>Total</td>
<td>8,197</td>
<td></td>
<td>1,904,823</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Students’ enrollment in secondary schools by school type

<table>
<thead>
<tr>
<th>School type</th>
<th>Number</th>
<th>% of total</th>
<th>Enrolment</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>5,082</td>
<td>62.13%</td>
<td>915,758</td>
<td>48.08%</td>
</tr>
<tr>
<td>Boarding</td>
<td>1,515</td>
<td>18.52%</td>
<td>672,594</td>
<td>35.31%</td>
</tr>
<tr>
<td>Day &amp; Boarding</td>
<td>1,404</td>
<td>17.17%</td>
<td>306,922</td>
<td>16.11%</td>
</tr>
<tr>
<td>Unknown</td>
<td>178</td>
<td>2.18%</td>
<td>9,549</td>
<td>0.50%</td>
</tr>
<tr>
<td>Total</td>
<td>8,179</td>
<td></td>
<td>1,904,823</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Students’ enrollment in secondary schools by school status

<table>
<thead>
<tr>
<th>School status</th>
<th>Number</th>
<th>% of Total</th>
<th>Enrolment</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>606</td>
<td>7.41%</td>
<td>343,309</td>
<td>18.02%</td>
</tr>
<tr>
<td>Female</td>
<td>1,095</td>
<td>13.39%</td>
<td>407,513</td>
<td>21.39%</td>
</tr>
<tr>
<td>Mixed</td>
<td>6,433</td>
<td>78.65%</td>
<td>1,149,182</td>
<td>60.33%</td>
</tr>
<tr>
<td>Unknown</td>
<td>45</td>
<td>0.55%</td>
<td>4,819</td>
<td>0.25%</td>
</tr>
<tr>
<td>Total</td>
<td>8,179</td>
<td></td>
<td>1,904,823</td>
<td></td>
</tr>
</tbody>
</table>

As the data show, the majority of students at secondary level go to public day mixed gender schools. The selection of students to join public secondary schools is done centrally by the MoE. However, the school a student eventually attends is determined in part by the parents’ ability to pay any fees that may be involved. This means that a student may have performed well enough to join a national school (all of which are boarding schools) but because of the inability of the parents to meet the cost of boarding, such a student may end up joining a day school.

The secondary school science curriculum. Science at secondary school level is taught as distinct subjects (i.e., biology, chemistry and physics). The three science subjects are compulsory in Forms One and Two (ninth and tenth grades). However, when the students get to Form Three (eleventh grade) they are required to take at least two of the sciences in which they also sit the KCSE, the national examination, taken at the end of the four years of secondary
education. What is taught and how it is taught in these subjects and others in the school curriculum is provided for in the national syllabus. In addition to providing guidance in terms of content to be covered, the syllabus also gives the objectives to be achieved for a given topic and the amount of time in weeks to be taken to cover the content. Thus, the syllabus is considered an important document in the Kenyan education system. It is centrally developed by the Kenya Institute of Curriculum Development (KICD), formally Kenya Institute of Education (KIE), for all the subjects in the school curriculum both at primary and secondary levels.

**The language of instruction.** The language of instruction from Standard Four (fourth grade) onwards is English for all subjects in the school curriculum except Kiswahili. Kiswahili which is taught as a language and one of the subjects is compulsory for all students both at primary and secondary levels. English as the language of instruction from Standard Four (fourth grade) onwards is a policy that was enacted in 1976 following recommendations by the National Committee on Educational Objectives and Policies. It overturned an earlier policy of instruction in English starting from Standard One by The Ominde Commission on Education of 1964. Prior to 1964, attempts to introduce English as the language of instruction had been made by the British white missionaries as early as 1919 but had failed due to lack of qualified teachers and teaching learning materials (Gorman, 1974). As such, English was only taught as a subject rather than used as the language of instruction. Kiswahili was, thus, used as the main language of instruction starting from Standard Four (fourth grade) with some teaching taking place in the community languages especially in the lower primary level (i.e., first through third grades). The use of community languages, for instruction in lower primary level, particularly in rural areas, continues to date.

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3 Kiswahili was until 2010 the national language (spoken by all communities but not in official places such as parliament and offices) when it became an official language just like English following the promulgation of the new constitution. Following its elevation to official status, Kiswahili can now be used in parliament and offices.
As to whether or not effective learning takes place when instruction takes place in English is a question that has been examined by scholars in Kenya (Bunyi, 1999; Kembo & Ogechi, 2009). Through classroom observation of lessons in subjects in the school curriculum mainly at the primary school level, research by these scholars has shown that English as a language of instruction limits access to meaningful learning of content in school subjects by students mainly from the rural areas. The students were found to be passive listeners to teachers during teaching. Their participation in the learning process came in the form of repeating verbatim sections of the teachers’ verbal communication. Kembo and Ogechi (2009) also surveyed a sample of the general population who included teachers regarding their opinions on the use of English as a language of instruction and found that most of them preferred children to learn in English. Kembo and Ogechi attributed this to the belief among the general population that English comes with social and economic prosperity. The concern for this study was not whether or not English should be used as a language of instruction. Rather its concern was, given the circumstances, how can students be supported to not only engage and participate in school science learning but also learn in meaningful ways especially by drawing on their ways of talking and by extension understanding of scientific phenomena from outside the classroom contexts.

**Statement of the Problem**

The government of Kenya (GoK) recognizes the important role science must play in helping achieve the country’s vision popularly known as Vision 2030 – to become a globally competitive and prosperous country by 2030 (GoK, 2007). The government also asserts that science can advance the vision and as a result, “more resources will be devoted to scientific research, technical capabilities of the workforce, and in raising the quality of teaching
mathematics, science and technology in schools, polytechnics and universities” (GoK, 2007, p. x). A key aspect to achieving this vision is a skilled workforce in science and mathematics. However, academic performance of students in the KCSE examination in mathematics and science continues to be dismal compared to other subjects in the school curriculum. Tables 4 and 5 show comparisons in academic performance of science subjects and a few other selected subjects for the years 2007-2010.

From the data in tables 4 and 5, it is only in mathematics and the sciences (biology, chemistry and physics) where percentage mean scores are consistently below those of other subjects for all the years, except in 2007 and 2008. In 2007, both physics and biology had higher mean scores than English while in 2008 physics had a higher percentage mean score than English. It might appear that students are performing better in physics than the other sciences; physics is usually selected by students who truly have interest in it (note the lower enrollments in physics than the other sciences). This likely indicates the higher mean in physics is as a result of a selection effect. As mentioned earlier, the KCSE is a national examination whose results are used to determine whether or not students proceed to university. Thus, poor performance in science and mathematics in this examination means that the number of students who proceed to university and enroll in science related courses is limited.
Table 4: Academic performance in KCSE examination in science subjects and other selected subjects in 2007-2008

<table>
<thead>
<tr>
<th>Subject and its Code</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of candidates</td>
<td>Mean (%)</td>
</tr>
<tr>
<td>231 Biology</td>
<td>245,911</td>
<td>41.97</td>
</tr>
<tr>
<td>232 Physics</td>
<td>83,273</td>
<td>41.33</td>
</tr>
<tr>
<td>233 Chemistry</td>
<td>266,761</td>
<td>25.39</td>
</tr>
<tr>
<td>121 Mathematics</td>
<td>273,134</td>
<td>19.74</td>
</tr>
<tr>
<td>101 English</td>
<td>270,629</td>
<td>39.69</td>
</tr>
<tr>
<td>102 Kiswahili</td>
<td>271,494</td>
<td>45.75</td>
</tr>
<tr>
<td>311 Hist. &amp; Gov.</td>
<td>163,910</td>
<td>50.92</td>
</tr>
<tr>
<td>312 Geography</td>
<td>102,849</td>
<td>46.82</td>
</tr>
<tr>
<td>313 C.R.E</td>
<td>164,285</td>
<td>62.40</td>
</tr>
</tbody>
</table>

Table 5: Academic performance in KCSE examination in science subjects and other selected subjects in 2009-2010

<table>
<thead>
<tr>
<th>Subject and its Code</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of candidates</td>
<td>Mean (%)</td>
</tr>
<tr>
<td>231 Biology</td>
<td>299 302</td>
<td>27.20</td>
</tr>
<tr>
<td>232 Physics</td>
<td>104 188</td>
<td>31.33</td>
</tr>
<tr>
<td>233 Chemistry</td>
<td>328 922</td>
<td>19.13</td>
</tr>
<tr>
<td>121 Mathematics</td>
<td>335 014</td>
<td>21.13</td>
</tr>
<tr>
<td>101 English</td>
<td>334 883</td>
<td>39.26</td>
</tr>
<tr>
<td>102 Kiswahili</td>
<td>334 822</td>
<td>38.57</td>
</tr>
<tr>
<td>311 Hist. &amp; Gov.</td>
<td>210 622</td>
<td>45.87</td>
</tr>
<tr>
<td>312 Geography</td>
<td>112 446</td>
<td>38.89</td>
</tr>
<tr>
<td>313 C.R.E</td>
<td>217 404</td>
<td>42.82</td>
</tr>
</tbody>
</table>
In Kenya, some scholars have devoted their time to research in science education (Ayere, 2000; Gichura, 1999; Kamau, 1996; Radho, 1996). However, much of it has been driven by the search for reasons behind students’ dismal performance in science in national examinations. Through such research a number of factors have been identified as being the cause of poor performance in science. They include student-related factors such as negative attitudes towards science (Gichura, 1999), school-related factors such as inadequate teaching and learning resources (Ayere, 2000), and teacher-related factors such as inappropriate teaching methodologies (Ayere, 2000; Kamau, 1996; Radho, 1996).

The MoE has put in place interventions to help mitigate the problem of poor performance in science and mathematics. Indeed the Strengthening of Mathematics and Science in Secondary Education (SMASSE) program, an in-service education and training (INSET) program started in 1998 for mathematics and science teachers, is one such intervention. The goal of SMASSE is to upgrade teachers’ competencies and skills in teaching methodology. The MoE’s hope was that by providing in-service training to the teachers, the problems of inadequate resources and students’ attitudes towards these subjects would also be addressed. This is because improvising equipment and materials for teaching science and mathematics for schools that do not have and improving students’ attitudes are two important aspects of teaching that are addressed in SMASSE. However, it has been more than a decade since the inception of SMASSE but the performance in both mathematics and science is still dismal.

Not much attention has been paid to students’ ways of understanding ideas in scientific phenomena outside the classroom, much less how students talk about the ideas and how the talk relates and influences science learning in the classroom. As mentioned earlier, the students in Kenya learn all subjects in the school curriculum except Kiswahili in English from Standard
Four (fourth grade) onwards. The majority of these students have other languages (community languages and Kiswahili) they can use to communicate with family members and peers outside the classroom. Thus, situations exist in Kenya where students may encounter English in the classroom only. Such possibilities are even higher in rural areas where some schools are attended only by students drawn from the community in which the school is located. While outside the classroom, students in such schools might find it more convenient and easy to communicate with each other in their community language as opposed to the language of instruction. Of more importance is that while outside the classroom students encounter and experience scientific phenomena that they may talk about either among themselves or with members of their families.

For example, students experience or observe phenomena such as water vapor or steam from cooking food or tarmac roads and rocks following rain on a hot day, dew on grass in the morning, dissolving of salt and sugar when added to food, light from different sources (i.e., flashlights, bulbs, the sun), phone charging using electricity, heat from fires and the sun, thunder and lightning, certain kinds of clothing clinging on their bodies or producing cracking sounds and or sparks when undressing especially in the dark, and rust on iron farm implements. Inherent in these phenomena are concepts students encounter in their science classrooms such as evaporation, dissolving, condensation, light, heat transfer, electricity, rusting and static electricity. When the students talk about ideas inherent in these phenomena in outside the contexts, they may do so in ways including language that are different from those emphasized in the science classroom.

The importance of language in learning in general (Shatz & Wilkinson, 2010; Vygotsky, 1978) and science in particular (Lemke, 1990) has been recognized. Indeed, Shatz and Wilkinson observe, “language skills affect every realm of social and cognitive life. It is the medium through
which culture is carried and education is attained” (p. 9). This means that meaningful learning may not occur unless attention is paid to the language as a medium through which learning is taking place. As mentioned, research conducted in Kenya, mainly at the primary school level, has shown that meaningful student participation in science is hampered due to challenges related to the language of instruction (Cleghorn, 1992; Kembo & Ogechi, 2009).

Furthermore, Khatete (1995) alluded to the idea of students’ first language influencing their understanding of science. He sought to determine students’ understanding of the idea of decomposition and its importance to nature, and food preservation procedures. The study involved students both at the primary and secondary school levels in Kenya. He collected data through questionnaires and conducted one-on-one interviews with selected students. To a question requiring students to state how boiling milk kept it fresh for some time, some students talked of bacteria escaping in “smoke.” According to Khatete, the students referred to water vapor produced when milk boils as “smoke” because there was no equivalent word for water vapor in the students’ community language, but also because their experiences with not just boiling milk but also cooking other foods involve the use of firewood, which is accompanied by smoke as it burns. He explained that the smoke from the burning wood combines with the water vapor from the boiling milk (or other foods) making it difficult to distinguish the water vapor from the smoke. Based on this study, it is clear that ways in which students understand, and in particular the language they use to talk about, scientific phenomena outside the classroom and how it relates and influences learning in the science classroom is an area science educators and researchers cannot afford to ignore.
Purpose of the Research and Research Questions

Through this research I sought to explore how secondary school students understand ideas involved in physical science phenomena both outside- and inside-the-classroom contexts through their talk. The purpose of this research was therefore to describe the students’ talk about ideas inherent in physical science phenomena both outside- and inside-the-classroom contexts. I also sought to describe the similarities and/or differences between the talk in both contexts and that emphasized in science classrooms, and discuss their implications (both theoretical and practical) in science learning. I utilized data I collected from seven Form Two students (three boys and four girls) from one public, mixed gender day secondary school in Kenya through focus group discussions as the students engaged in talking about ideas inherent in given physical science phenomena and activities. I supplemented these data with data from one-on-one semi-structured interviews with two teachers (one chemistry teacher and one physics teacher). I also examined the students’ responses to questions on teacher-made assessments involving the ideas and phenomena I investigated, in addition to the syllabus for content and objectives requirements for the said ideas. In this regard, this research sought to answer the following questions:

1. How do secondary school students talk about physical science phenomena in an outside-the-classroom context?
2. How do secondary school students talk about physical science phenomena in an inside-the-classroom context?
3. What are the similarities and/or differences between how the students talk about physical science phenomena in both contexts and that in a science classroom?
4. What are the implications of how students talk about physical science phenomena in both contexts for teaching and learning science?
Significance of the Research

Research has been conducted that shows that SLSL2 experience challenges in learning science arising from not only the content and language of science but also the language of instruction being different from the students’ first language. Scholars have also investigated ways in which such students can be made to engage and participate in science learning in meaningful ways. Arising from such research, everyday ways of making sense of the world and the students’ first language have been shown to be useful tools for engagement and participation in science (Ballenger, 1997; Blake & Van Sickle, 2001; Brock-Utne, 2007; Cleghorn, 1992; Warren et al., 2001). However, most of the research studies involving students from diverse cultural and linguistic backgrounds were conducted with students from predominantly two linguistic backgrounds (i.e., Hispanic and Haitian Creole) mainly at the elementary school level learning science ideas in the life sciences. The majority of the studies also focused on classroom communication patterns between the teacher and the students and between students themselves. This research examined how secondary school students understand ideas involved in scientific phenomena both outside- and inside-the-classroom contexts through their talk, and the relationships between the talk in both contexts. Knowing how students’ talk about ideas inherent in scientific phenomena in the-outside-classroom contexts could provide teachers with tools and background information to leverage students’ backgrounds (i.e., cultural and linguistic) for science learning (Fradd & Lee, 1999). When students learn science in ways that are related to their everyday experiences and talk, science learning becomes more meaningful and relevant (Lee, 2004). Thus, the findings of this study are likely to contribute towards enhancing the effectiveness of science teaching for SLSL2. Additionally, the findings of this research are going to add to the steadily growing body of knowledge on cultural and linguistic influences on science
learning in terms of not just widening the scope and variety of linguistic backgrounds but also in terms of school level (i.e., high school as opposed to elementary level) and with phenomena in the physical sciences as opposed to life sciences.

**Theoretical Framework**

It is a reality that some students find the learning of science relatively easy while others do not. While some scholars explain this phenomenon away in terms of failure of instruction to change or modify ideas in science that students hold as they come to class, other scholars prefer to look beyond students’ ideas and include culture and language as playing an important role in science learning. This research recognized the role of social setups as rich points for learning with culture and language mediating the learning process (Lemke, 1990; Shatz & Wilkinson, 2010; Vygotsky, 1978) and draws on Aikenhead and Jegede’s (1999) ideas of “cultural border crossing” and “collateral learning” (p. 271) and Moje et al.’s (2001) idea of “third spaces” (p. 489) as theoretical and empirical underpinnings that guided the investigation. In the following sections, I discuss these frameworks under the headings of science learning as movement into another culture and third spaces in science learning.

**Science learning as movement into another culture.** Some scholars view science as a culture and the language of science as its cultural tool. Based on this view, learning science means moving into the culture of science and acquiring the language of science that enables one to “talk science” (Lemke, 1990, p. 1). The view that science learning involves movement into the culture of science recognizes that students have their culture, which may be different from that of the science classroom. Indeed, the culture of the science classroom has been associated closely with Western culture (Aikenhead, 2001; Asabere-Ameyaw, Sefa Dei, & Raheem, 2012;)

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^4 Culture and language are inseparable (Heath, 1983; Shatz & Wilkinson, 2010). Therefore in the use of the term culture, everyday language and ways of making sense of the world will be implied.
Kawagley et al., 1998; Ogunniyi, 1988) mainly because of its method of understanding how the world works (i.e., putting objectivity up front, and linking phenomena to cause-effect). On the other hand, in some non-Western cultures, including traditional African communities, phenomena are not viewed in terms of cause and effect; rather they are viewed in terms of what they symbolize (Akponglo-Nartey et al., 2012), with religion and folklore playing a pivotal role in people’s sense making and understanding of the way the world works (Khatete, 1995).

Also, the way phenomena are talked about and labeled in the indigenous languages in these communities may mean different things in another language and in science. For example, the phenomenon of water evaporating from cooking food is referred to as “smoke” in some communities in Kenya (Khatete, 1995). Coming to the science classrooms with this kind of understanding and talk puts the students in a situation where they will need to shift to new ways of understanding and talk where they not only recognize the phenomenon and label it as evaporation but also recognize that the substance produced is water that is in a different form or state (i.e., gaseous) and label it as water vapor rather than “smoke.” When such a shift takes place, an important step in science learning occurs. Aikenhead and Jegede (1999) use a social term cultural border crossing to describe this step and explain it using the idea of collateral learning.

Aikenhead and Jegede (1999) conceptualized school science learning as cross-cultural border crossing from the students’ everyday culture to the culture of science and the science classroom. While there may be no physical borders to be crossed in the science classroom, one might imagine a cultural border crossing as representing a cognitive shift where a student views and makes sense of the world in new and perhaps unfamiliar ways. Aikenhead and Jegede used the words, smooth, manageable, hazardous and impossible, derived from Costa’s (1995) work
with students regarding their transition between the culture of their families and that of school science, to describe the ease with which cultural border crossing can occur. According to Costa, students’ transitions are *smooth* when the cultures of family and science are congruent, *manageable* when the cultures are somewhat different, *hazardous* when the cultures are diverse and *impossible* when the cultures are highly discordant. Aikenhead and Jegede argued that the success with which cultural border crossing occurs is dependent on the degree of the difference between the student’s life-world culture and the culture of the science classroom, the student’s perception of the difference between the two cultures and any assistance provided to the student. This implies that students’ whose everyday culture is diverse or discordant with the culture of the science classroom could experience a smooth or manageable cultural border crossing if they viewed their everyday culture as not conflicting with the culture of the science classroom. It further implies that students can be assisted to make successful cultural border crossings into the culture of the science classroom even when their everyday cultures and those of the classroom seem discordant.

Aikenhead and Jegede (1999) argued that although students may experience one or the other of the four types of cultural border crossings, not all of them lead to learning that integrates the students’ everyday culture and that of science classroom into their mental schemas. They used the term collateral learning to represent learning that achieves this integration. They conceptualized collateral learning as the ability to hold onto two or more conflicting schema in the long term memory at the same time. For students whose everyday culture is significantly different from that of the science classroom, collateral learning might mean constructing “scientific concepts side by side and with minimal interference and interaction, with their indigenous concepts (related to the same physical event)” (p. 277). Aikenhead and Jegede
identified four types of collateral learning; namely parallel, simultaneous, dependent, and secured, which they depicted as points on a spectrum with parallel and secured collateral learning representing the two ends of the spectrum. According to them, parallel collateral learning occurs if there is no interaction between two or more conflicting schemas while secured collateral learning occurs if there is interaction among the schemas.

Using the earlier example of “smoke” for water vapor, one could imagine that if a student has this understanding arising from his/her everyday experiences and language and undergoes parallel collateral learning in science such a student would hold both the everyday understanding and the scientific understanding in his/her schema. So that when presented with phenomena in a way s/he experiences them outside the classroom s/he will talk about them in ways that reflect and conform with the everyday talk about the phenomena, but use the language of the science classroom when the same phenomena are presented in ways s/he experiences them in a science class, thus revealing no connection between outside-the-classroom talk and that of inside-the-classroom. On the other hand, secured collateral learning would be thought of as having occurred if the student draws on his/her science understanding from the science classroom to explain the occurrence of the phenomenon outside the classroom.

Guided by Aikenhead and Jegede’s (1999) ideas of border crossing and collateral learning, I probed the students and documented their talk about the phenomena investigated in this research. I was particularly keen to pick the words, phrases the students used to describe and explain the occurrence of given phenomena. The phenomena I used in this research are those involving concepts students encounter in their science classroom such as dissolving, evaporation, and condensation addressed in chemistry and static electricity and current electricity addressed in physics. These concepts are inherent in phenomena and activities students encounter in their
everyday lives, such as water vapor from cooking food or tarmac roads and rocks following rain on a hot day, dew on grass in the morning, addition of salt and sugar to food, light from flashlights, thunder and lightning, clothes clinging to their bodies or producing cracking sound and or sparks when undressing especially in the dark. I analyzed how students talked about ideas involved in these phenomena and activities against how they talked about concepts they had learned involving the same phenomena from their science classroom. This revealed the nature of differences and/or similarities between the students’ talk in the two contexts. Also of interest was whether or not students saw relationships between a phenomenon as experienced outside the classroom and those learned inside the classroom. This pointed to the type of collateral learning students may have experienced while inside the science classroom.

Aikenhead and Jegede (1999) acknowledged that a cultural border crossing into the culture of science classroom is not easy and therefore students need assistance. However, they were not clear on the kind of assistance needed. In the context of learning science, one would think that a teacher would play a critical role in providing an enabling environment that allows students to negotiate cross-cultural border crossings between the students’ life cultures and that of the science classroom and therefore the kind of assistance alluded to by Aikenhead and Jegede is one that should be provided by the teacher. This leads me to Moje et al.’s (2001) idea of third spaces in science learning.

**Third spaces in science learning.** This research also draws on the work of Moje et al. (2001) regarding creation of “third spaces” as a way of making science learning more meaningful and relevant to the learners, especially for SLSL2. Moje et al. described a study involving students from non-mainstream backgrounds learning science using project-based curricula. The study involved seventh graders, whose home language was Spanish, and their
bilingual English-Spanish teacher. Moje et al. collected data through classroom observation, students’ written work and interviews with the teacher and the students. Drawing on Gee’s (1996) work, Moje et al. adopted the term Discourses, which Gee used to represent “ways of knowing, doing, talking, reading, and writing, which are constructed and reproduced in social and cultural practice and interaction” (p. 470). While acknowledging that during science teaching in a given classroom, there can be several different Discourses, Moje et al. identified three types of Discourses mediating students’ learning in such a classroom. They referred to these as (a) discipline or content Discourse – involving specialized language of science, (b) classroom Discourse – involving classroom interactions between the teacher and students with culture and language playing a pivotal role in those interactions, and (c) social or everyday Discourse – involving everyday ways of making sense of the world that students bring to the classroom. They found that there was a conflict between the content Discourse and students’ everyday “Discourses and knowledges” (p. 488).

According to them, the content Discourse placed demands on students that were difficult to reconcile with their everyday Discourse and knowledges despite efforts made by the teacher. For example, in one activity students were required to investigate and answer the question “what is the quality of water in our river?” (p. 468). The teacher used both English and Spanish to explain the task to the students but the term “quality” was not clear to students. The students never used the term in their writing but instead focused on pollution and how to stop it. Moje et al. argued that when there is any conflict between the three Discourses, then meaningful science learning is hampered. These researchers noted that creation of a third space where science content Discourse and students’ everyday Discourses are integrated can lead to more meaningful learning. It seems then that a teacher has a crucial role to play of facilitating the creation of third
space. A teacher may need to not only recognize that students’ everyday Discourses and knowledges are different from those of the science classroom but also help students in integrating those Discourses and knowledges with the ones in the science classroom.

Although students in Kenya may not be thought of in terms of coming from mainstream and non-mainstream backgrounds, learning science in a language other than their first language (especially for those learning in day schools in rural areas) is likely to make their everyday Discourses and knowledges different from that of science content. Drawing on Moje et al.’s (2001) idea of third space, I interviewed one chemistry teacher and one physics teacher on how they teach concepts involving phenomena examined in this research. I listened keenly to understand whether or not the teachers were aware of ideas students might bring to the science classroom from their everyday experiences with phenomena outside the classroom and ways in which they drew or did not draw from such ideas in their teaching. These provided me with ideas regarding efforts or lack of them by teachers to create third spaces in the science classrooms.

Figure 1 summarizes what I conceptualize as cultural border crossing, collateral learning and third spaces in science learning involving SLSL2.

Figure 1 represents three hypothetical spaces SLSL2 can occupy. The first one is everyday culture and includes students’ everyday ways of making sense of the world and everyday language. The second one is the culture of the science classroom and includes the language of instruction, the language of science and science ideas and conventions. The third one represents third spaces where everyday and scientific ways are integrated.
Figure 1: Schematic representation of cultural border crossing, collateral learning and third space in science learning

The first space and the second space are separated by a thick line, which represents a cross-cultural border between the students’ everyday culture and the culture of the science classroom. This border is restrictive to the smooth movement of the students from their everyday culture and ways of making sense of the world and the culture of science classroom. I conceptualize the starting point of all students as being the everyday culture where I have categorized the students into three groups X, Y and Z. X represents a group of students who view science and related ideas as being too difficult to understand; therefore, the border is too restrictive for them to cross into the culture of the science classroom. These students remain in their everyday culture. According to Aikenhead and Jegede (1999), such students easily drop out of science and may drop out of school altogether. It is also possible that these students could be in class only physically and show total lack of interest in science through behavior such as sleeping in class, and non-participation. In talking to such students, one could possibly observe an enthusiasm in their speech and character as they talk about scientific phenomena in their
everyday lives and none when they talk about science in the classroom. Additionally, such students may mimic aspects of the science classroom culture such as adoption of scientific terminologies and language in communicating (verbally or in writing) about ideas in science without developing the necessary conceptual understanding that accompanies them.

Y represents a group of students who are able to cross the border from their everyday culture into the culture of the science classroom and therefore achieve parallel collateral learning as represented by two parallel arrows running in opposite directions across the border into both the everyday culture and the culture of the classroom. For this group of students, the border is not restrictive and therefore they move freely between the two cultures and have developed schemas for understanding the way the world works from the standpoints of both their everyday culture and the culture of the science classroom. However, the understandings run counter to one another. These students may, for example, see no connection between the scientific phenomena in their everyday lives and those in the science classroom. They may recognize and talk about scientific phenomena using their everyday language, based on their everyday experience, without making reference to their understanding from the science classroom. Likewise they may recognize and talk about scientific phenomena in their science classroom and not relate that to their understanding and talking in their everyday lives.

Lastly, Z represents a group of students who have achieved secured collateral learning as represented by a single double headed arrow. Just like students in group Y, these students move freely between the two cultures with the difference being a recognition that even though scientific phenomena may be labeled and talked about differently in everyday language compared to that in the science classroom, they represent one and the same thing regardless of whether or not it is inside or outside the classroom. As such, this group of students may explain
scientific phenomena in their everyday lives using their understanding gained from the science classroom. According to Moje et al. (2001), the creation of third space helps achieve this kind of understanding. In this regard, third space is facilitative to the integration of everyday understanding of science and that of the science classroom. Apart from third space serving a facilitative role, it could also be a destination for students who have acquired secured collateral learning where the students no longer view everyday understanding and classroom understanding of science as separate entities. The double headed arrow to and from the arrow representing secured collateral learning illustrates this dual function of the third space. Also the position of the third space in Figure 1 is illustrative of the idea that whether it is serving a facilitative function to secured collateral learning or as a destination following secured collateral learning, it happens in the neighborhood of the science classroom.

These two frameworks were useful for me not just in conceptualizing this research but also in analyzing the data. As I have explained in Chapter Three I derived some of my initial codes based on the ideas involved in these frameworks.

**Chapter Summary**

This chapter provides the background to the study that includes the problem statement and rationale for conducting it. It also outlines the research questions and provides the theoretical underpinnings that guided the research. I have argued that students’ understanding of science ideas in outside the classroom contexts and how the understanding and accompanying talk relates to the understanding and talk about the same ideas inside the classroom needs to be examined. This is an area that remains unexplored. Information arising from such an investigation would be a useful tool for leveraging students’ understanding of science in the classroom. In the next chapter, I present the review of related literature.
Chapter Two – Literature Review

Introduction

Some scholars for example, Aikenhead and Jegede (1999), Cobern (1996), and Cobern and Aikenhead (1998) believe that students come to science classrooms with cultures and language that allow them to explain the way the world works even before they learn science. Thus, for them, learning science means adapting into the culture of the classroom. This belief could be behind the unprecedented growth in research, especially that involving SLSL2, in the last two to three decades. Research conducted has been both wide and varied in foci. While some scholars chose to investigate science learning involving SLSL2 inside the classrooms, others have been more concerned with communities and how they make sense of the world. Through their work, several bodies of research have been developed that include cultural knowledge and science learning, and language and science teaching and learning. I reviewed this literature to determine what has been done and identify areas that need further research. In this chapter, I present the reviewed literature beginning with cultural knowledge and learning in school. This will be followed by reviewed literature on science learning and language and later by that on teaching science to SLSL2. The chapter concludes with a summary of the reviewed literature.

Cultural Knowledge and Learning in School

The idea of cultural knowledge and school learning has occupied a central position in the work of some scholars since the 1990s although different scholars label it differently. Some scholars refer to this knowledge as “indigenous knowledge” (Aikenhead, 2001; Akpanglo-Nartey et al., 2012), while others refer to it as “funds of knowledge” (Moll, Amanti, Neff, & Gonzalez, 1992). To others, for example, Gitari (2009) and Ng’asike (2011), it is “everyday knowledge” and “cultural practices,” respectively. Yet for others, this knowledge connotes “worldviews”
(Cobern, 1996; Kawagley et al., 1998). For purposes of this research and this literature review, I will adopt the term cultural knowledge mainly because of its roots and origin in a given people’s culture. Also, much like culture is a way of life (e.g., talking and acting) of a given group of people (Gee, 2005; Heath, 1983; Lemke, 2001; Purcell-Gates, 1995), I view cultural knowledge with respect to science as a way of understanding about the way the world works from a perspective of a given group of people. How that understanding and the related talk differs or is congruent to the scientists’ view of the way the world works are of prime importance to this research. Similarly, how the ideas arising from such talk can be integrated in school science to enhance students’ learning in science is equally important. The reviewed literature in the following sections seeks to answer the questions of not only the similarities and differences between cultural knowledge and scientific knowledge, but also cultural explanations for the way the world works and how cultural knowledge can be integrated with school science.

**Similarities and differences between cultural knowledge and school science.** With regard to similarities between cultural knowledge and scientific knowledge, scholars argue that cultural knowledge about the way the world works is a reliable and authentic body of knowledge, just like scientific knowledge (Aikenhead, 2001; Kawagley et al., 1998; Ogunniyi, 1988; Sniverly & Corsiglia, 2001). Similarly, they argue that cultural knowledge shares some of the methods with science such as observation “as people go about their business in everyday lives” (Gitari, 2009, p. 264). However, there are significant differences between some of the ways of constructing cultural knowledge and scientific knowledge. One method of constructing cultural knowledge that is different from that of science is insight that may be accompanied by spiritual inspiration (Aikenhead, 2001; Asabere-Ameyaw et al, 2012; Kawagley et al., 1998). It seems that the spiritual connection to cultural knowledge could be one of the reasons behind some
students’ (particularly those from non-Western cultures) inclusion of God in their responses to questions requiring their conceptual understanding of scientific ideas. For example, in a study that sought students’ understanding of ideas related to decomposition (Khatete, 1995), students were asked to explain what happens to animals and plants when they die. Some students gave responses such as “When animals or plants die they then become soils because they are made of soils” (p. 185) and “God made us from soil, so the animal cannot become anything else except soil” (p. 186). These responses clearly show an adherence to understanding of ideas beyond science to include religion or spiritual understanding.

Other differences between cultural knowledge and scientific knowledge arise largely in the way the two forms of knowledge are passed on to younger generations. While scientific knowledge is passed to students through formal instruction in schools, cultural knowledge lacks such formal structures for learning. Rather it is passed on to youth through several methods and strategies that vary from community to community. This is mainly because of the differences that exist in terms of what is valued as cultural knowledge by different communities. Furthermore, some of the cultural knowledge in a given community (i.e., blacksmithing, traditional healing) may be a preserve of a specific group of people and therefore passed on to the younger generation by participation in “apprenticeships in specific families through successive generations” (Gitari, 2009, p. 264). Some of the methods of gaining cultural knowledge by the younger generation include listening to stories and observing the older members of the community (Aikenhead, 2001; Gitari, 2009; Kawagley et al., 1998). In some cases, while the knowledge is being learned there may be very little or no verbal communication between the learners and the teacher (Kawagley et al., 1998).
Based on this review of literature, it is clear that there are similarities and differences between cultural knowledge and scientific knowledge especially in terms of methods of constructing the two forms of knowledge and ways of passing it to the younger generations.

What are the cultural understandings for how the world works and how do they influence science learning? Below is a literature review on cultural knowledge about natural phenomena and science learning.

**Cultural explanations for natural phenomena and science learning.** Explanations for natural phenomena have been sought. For example, Pauka, Treagust, and Waldrip (2005) investigated what explanations village elders and high school students from Papua New Guinea had for natural phenomena such as erosion, thunder and lightning, and the rainbow. They collected data through interviews with village elders and through student questionnaires. They found that the village elders had explanations for the causes of the phenomena that included spirits, spells and magic. On the other hand, most of the students provided explanations for the occurrence of phenomena based on the knowledge learned in school science but some chose explanations such as those provided by the elders. Pauka et al. explained that the idea that the questionnaires were administered in school, could have contributed to the students’ explanations for the phenomena based on science learned in school and hence minimized the ability to uncover their traditional knowledge about the phenomena. In other words, the school set up may have influenced the student’s responses. What is clear from this study is that there is alternative knowledge and understanding about natural phenomena. Also clear is the idea that students can turn to traditional knowledge in explaining the occurrence of scientific phenomena.

The influence of cultural knowledge about phenomena on science learning has been documented (Akpanglo-Nartey et al., 2012; Jegede & Oke Kubola, 1991). Akpanglo-Nartey et al.
investigated students’ understanding of scientific ideas involved in living things, and natural phenomena such as rain, thunder, lightning, drought, tides, and human activities such as fishing and farming. The study, conducted in Ghana, involved 550 students at fifth, sixth, Junior One and Junior Two grade levels selected from 55 schools drawn both from big towns/cities and small towns/village setups. It also involved 60 science teachers from the selected schools. The researchers collected data from the students and the teachers through questionnaires. The student questionnaire was based on ideas in the school syllabus and what students observed in their everyday lives. Besides questionnaires, the researchers also conducted group discussions with students on ideas about the phenomena in question. The researchers found that the students’ understanding of the phenomena was influenced by forms of knowledge other than science. The researchers identified these as “indigenous knowledge” and “religious knowledge.” For example, to the question of why a child would resemble the mother, a student responded “the mother has stronger blood” (p. 65). Another student who did not think that there was a scientific explanation for children resembling their parents responded “I don’t believe there is a scientific explanation for children looking like their parents, because, the scientists were not there when God was creating human beings” (p. 65).

Based on these responses, it is clear that understanding about scientific phenomena from outside-the-classroom can filter into students’ explanations of the phenomena. Jegede and Okekubola (1991) established that there was a relationship between African traditional cosmology and students’ acquisition of the skill of observation, which is one of the process skills in science. Working with a group of 319 pre-degree science students from one of the universities in Nigeria, the researchers collected data through the use of two instruments – Traditional Cosmology Test (TCT) and Test of Observational Skills (TOS). The students responded to items
on the TCT about nature, and while using items on the TOS, they were required to make observations of biological structures and processes. The researchers found that the students who had a high level of belief in African traditional cosmology made significantly fewer correct observations compared to those who had a low level of belief. This study and others preceding it (i.e., Akpanglo-Nartey et al., 2012; Pauka et al., 2005) show that there is not only cultural understanding about phenomena but also a potential exists for such understanding to influence students’ learning in science. However, it is not just in science where there is parallel knowledge outside the classroom as well as cultural influences on students’ learning. My review of the literature showed that knowledge outside the classroom in content areas other than science has been investigated. In the following section, I present reviewed literature on cultural knowledge and cultural influences on learning in other content areas.

**Cultural knowledge and cultural influences on learning in other content areas.**

Scholars have investigated about cultural knowledge and cultural influences on learning in content areas other than science (Heath, 1983; Millroy, 1991; Moll et al., 1992; Purcell-Gates, 1995). Millroy describes a study in which she investigated mathematical ideas of a group of carpenters. She conducted the study in South Africa with a group of carpenters in whose workshop she served as an apprentice for six months during which period she collected data through observation, artifacts’ collection, and formal and informal interviews with the carpenters. She reported a case of two of the carpenters who were involved in and used ideas that may not be recognized as conventional mathematics (specifically, geometry) in solving the problem of how to determine that a square (an instrument used in carpentry) was true. Millroy concluded that even though the two carpenters did not go beyond middle school, they were involved in what she referred to as “mathematizing,” which included counting, measuring,
locating, designing, playing and explanation practiced mostly through pantomiming and miming. This study, just like those in science education (i.e., Aikenhead 2001; Kawagley et al., 1998; Ng'asike, 2011) shows that there is knowledge outside of the classroom that people may draw upon in solving real-life problems. This knowledge can also be used to leverage students’ learning in the classroom. Moll et al. (1992) demonstrated this through their study that involved one student and his family of Mexican background. They collected data through observation and interviewing. The researchers found that the student’s home and family had a rich source of knowledge they referred to as “funds of knowledge”—“historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being” (p. 133). For example, they found that the student was involved in several activities outside the classroom that included playing with his cousins, wandering freely most of the town, visiting a pharmacy owned by his aunt and visiting ranches among others. These, according to the researchers could not be taken for granted: “one of the things we learned about the Lopezes that we didn’t know before was the depth of the multicultural experiences their son, Carlos had in cross-border activities. It wasn’t just a superficial experience for him” (p. 136). Moll et al. argued that “funds of knowledge” had the potential for use in learning in school not just in one content area but several. They observed, “We did cover many areas of curriculum in one short week—math, science, health, consumer education, cross-cultural practices, advertising and food production” (p. 139). This means that knowledge from outside-the-classroom has a wide applicability, not just in the lives outside, but also in the classroom in learning.

Drawing on knowledge outside-the-classroom in leveraging students’ learning requires not only the teachers’ familiarity with the students’ culture and knowledge outside the classroom but also the ability and willingness to help students build on that knowledge and cultural ways.
This was illustrated by Heath (1983) through her ethnography of communication with two communities – Trackton, a black working class community and Roadville a white working class community. The two communities which were only a few miles apart, had deep cultural differences not only in their language but also how they socialized their children on language and its use. While there was structure in Roadville where the children were introduced to language through reading and telling of stories, such structures were lacking in Trackton. Rather, the children in Trackton relied on non-verbal cues observed from the older members of their community not only for action, but those cues also formed the basis for their language development. None of these ways, however, matched those of the Townspeople (the mainstream black and white people) where the children from the two communities attended school. As a consequence, the success in school of the students from the two communities was limited with those of Trackton falling far behind those of Roadville. Working with the teachers of Townspeople, the researcher helped them to draw on the students’ ways with language in their communities to leverage their learning in school. Heath observed:

Students engaged in a process of self-awareness by which they, in a sense, reconstructed a social and cognitive system of meanings. In this reconstruction however, they neither reserved classroom ways of learning for school only nor did they destroy or replace the community habits of knowing and using language they had brought to school. (p. 356)

What is clear from the strategy of drawing on students’ ways to leverage their learning in school is that it does not necessarily mean abandoning their communities’ ways.

The idea that there was cultural understanding about content students are likely to encounter in school, and especially science, calls for the need to harmonize or integrate such understanding with the one that occurs inside the classroom for purposes of enhancing
meaningful science learning. This brings me to the question of how school science can be integrated with cultural knowledge about phenomena.

**Integrating cultural knowledge with school science.** The belief by some scholars that students come to science classrooms with cultures and language that allow them to understand the way the world works makes for an argument that the goal in science education for students, especially those from non-Western backgrounds, should be to integrate their cultural knowledge with school science (Aikenhead, 2001; Akpanglo-Nartey et al., 2012; Asbere-Ameyaw et al., 2012; Ng’asike, 2011). This, they argue, makes science learning more relevant to the lives of the students. It also helps students to experience what Cobern and Aikenhead (1998) refer to as “autonomous acculturation” – “a process of intercultural borrowing or adaptation of attractive content or aspects of another culture and incorporating them or assimilating them into those of one’s indigenous or everyday culture” (p. 42). They prefer autonomous acculturation to mere acculturation because they believe that it minimizes on the risk of students wanting to wall off or create a compartment of scientific knowledge only retrievable in situations such as exams Cobern (1996). Integration of cultural knowledge with school science is also likely to help in easing tensions or conflicts that may exist between the two forms of knowledge.

The question of how cultural knowledge can be integrated in school science has been examined by some scholars. For example, Aikenhead (2001) uses the idea of “rekindling traditions” (p. 341) to illustrate how this can be achieved. He described a project in which he collaborated with six teachers, together with the Aboriginal elders from northern Saskatchewan, Canada, in developing and using content units that integrated Aboriginal cultural knowledge and school science. According to Aikenhead, an important aspect of the units used in the teaching was the presence of themes significant to the Aboriginal community, including respect for the
Aboriginal knowledge. He noted that the teaching was practical oriented and included activities such as going on a snowshoe hike or finding indigenous plants that heal. Aikenhead observed that one of the key elements in successful integration of cultural knowledge and school science involves the science teacher adopting the identity of a “cultural broker” – a person who “identifies the culture in which students’ personal ideas are contextualized, and then introduces another cultural point of view” (p. 340). Central to the idea of a cultural broker is the need for the teacher to be familiar with the students’ ideas and understanding in an outside-the-classroom context.

Kawagley et al. (1998) provided another example of how cultural knowledge can be integrated with school science. They described a lesson conducted by an Alaska native student teacher with a group of six students in third to seventh grade levels. In the lesson, the student teacher asked the students to design an experiment, but gave no clue as to what experiment the students were to design. According to Kawagley et al., the students decided to design an experiment that would enable them know the best substance to use for the removal of hair from caribou hides. Without any guidance from the adults in the class (i.e., student teacher, researcher and Yupiaq elders), the students decided to test a variety of substances that included laundry soap and caribou brains. This is due to the fact that the students had seen someone using caribou brain on the hides during their processing. Kawagley et al. noted that a father of one the students provided them with caribou brain from a skull of a caribou he had recently killed. The students then proceeded to soak samples of hides in different substances and left them for 24 hours, after which they tried scraping the hair from the hides to no avail. When the students noted that no form of guidance was forthcoming from the adults (one of whom was a grandmother with much experience in preparing caribou hides who had been observing them all along), they
“spontaneously asked the grandmother what they could do differently” (p. 141). Kawagley et al. observed that the grandmother explained the process of preparation of caribou hides, which involved soaking the hides in the river for several days followed by the application of the caribou brain on the hides for tanning purposes. Kawagley et al. argued that the students combined their knowledge from their everyday experiences and experimentation techniques learned in school science to pursue their ideas and only sought help when they thought that they had exhausted all the options.

This literature seems to point to a form of knowledge that is highly valued by communities it serves mainly because it is knowledge that the communities have relied upon for survival through the ages (Aikenhead, 2001; Kawagley et al., 1998; Ng'asike, 2011). Integrating cultural knowledge in school science is one way such knowledge can be propagated from one generation to another. It is also one of the ways through which science can be made relevant to the students (Ng'asike, 2011). However, more important are questions of whether or not teachers are aware of cultural knowledge students hold about scientific ideas they teach in science and ways of incorporating that knowledge in their science teaching. In the following section, I present a review of literature with regard to research on cultural knowledge and science learning in Kenya.

**Cultural knowledge and science learning in Kenya.** The idea of cultural knowledge and science learning has been investigated in Kenya (Gitari, 2009; Ng'asike, 2011). Through such research, the need for science instruction and curriculum that are relevant to the lives of the students has been raised. In addition, recommendations have been made with regard to science teaching that allows students to understand not only the differences between cultural knowledge and scientific knowledge, but also cultural knowledge as a form of knowledge that has the
potential in helping to solve real life problems. With regard to relevance, Ng’asike (2011) described what it might look like through his own experience of teaching science to children from the Turkana community in Kenya. He described how he conducted an experiment to demonstrate the idea of pressure exerted by different surface areas. As the lesson progressed, he asked the students to give examples of surface areas that exert pressure. He noted that the students spontaneously named hooves of animals such as donkeys, goats and camels. He observed that he was surprised when the students went ahead and arranged the hooves in order of those that exerted greater pressure to those that exerted less pressure. Ng’asike argued that despite the absence of examples given by students in learning materials such as textbooks, they represented accurate ideas on pressure but more importantly, they were relevant to the everyday experiences and lifestyles of the students. This is because the Turkana people live a nomadic lifestyle. The main source of their livelihood is keeping livestock which include camels, cows, sheep and goats that they move with from place to place in search of water and pasture. Thus, students were familiar with imprints of the different animals that formed the livestock of their community.

With regard to the use of cultural knowledge in solving problems in life, Gitari (2009) investigated an understanding and common use of everyday knowledge among high school students from the Meru community in Kenya. Gitari conducted the study with 52 Form Two (tenth grade) students from one high school. Among other things she sought to determine were students’ awareness about everyday knowledge and its use together with scientific knowledge acquired in school to solve practical problems. She utilized a variety of methods to collect data from students which included pre- and post-lecture questionnaires and observation of students’ group debriefing sessions following their interviews with elders in their community. Gitari found
that while a number of students were initially not able to differentiate between everyday knowledge and scientific knowledge, those who made a distinction viewed everyday knowledge as being “static and mundane” (p. 273). However, following the lecture, students’ ideas changed, especially with regard to science being process driven and the need to use scientific knowledge in solving real life problems. Gitari recommended that students need to be taught explicitly not only the differences between everyday knowledge and scientific knowledge, but also the use of both forms of knowledge in solving life problems.

Based on the findings of this study, the initial inability of the students to distinguish between everyday knowledge and science knowledge might mean that students had not viewed everyday knowledge as a distinct form of knowledge that may influence not only their everyday lives and their understanding of the way the world works, but also their understanding in school science. Students have been shown to be aware of science outside the classroom through their practices (Masingila, Muthwii & Kimani, 2011). Masingila et al. investigated out-of-school mathematics and science practice with students in standard six and eight (sixth and eighth grade) in Kenya. They found that a higher percentage (86%) of students had a broader view of science than those who had a broader view of mathematics (19%). Masingila et al. defined a broader view of mathematics and science to include ideas such as mathematics is a way of thinking, and science is what the world looks like or the searching of ideas. They attributed the higher percentage for the broader view of science to the chores students get involved in at home, such as cooking, cleaning and working on farms with plants and animals. Although this study did not investigate cultural knowledge and science learning, the high percentage of students who held broader views of science might mean that students see and experience science in their everyday activities outside-the-classroom. As and when they do, students may develop an understanding of
the way the world works through their everyday activities. These ways, which may also include the language used in talking about the way the world works, are part of what this research sought to unveil. In the following section, I present a review of literature on science learning and language.

**Science Learning and Language**

Just like cultural understanding about the ways the world works, issues of language and science learning have also occupied center stage in the work of some scholars in science education. This is partly because SLSL2 have been shown to experience challenges in learning science related to not only the content and language of science, but also the language of instruction being different from the students’ first language (Brock-Utne, 2007; Brown & Ryoo, 2008; Duran et al., 1998; Luykx et al., 2008). In this section, I present a review of literature on science learning and language under the following headings, science and its language as a culture, science learning in a second language, and everyday ways of making sense of the world and students’ first language in science learning.

**Science and its language as a culture.** The idea that science is a culture and learning it means acquiring the language of science to enable one to talk science (Lemke, 1990) is illustrated by a study that was conducted to investigate students’ perceptions of the culture of the science (Brown, 2006). The study involved 29 ninth, tenth and eleventh graders taking an introductory life science class. The students who participated in this study came from diverse ethnic and cultural backgrounds, but were all native speakers of English. Brown collected data through focus group interviews as he engaged the students in conversations about their perceptions of the culture of the science classroom. Brown found that students’ views depicted science as a subject that has a language that is different from everyday language. According to
them, the language of science had “big words” and was one that could only be used in a science classroom: “you can’t go out right now and say, I want a beaker,… so if you take a beaker into a science class, and you say, okay, let’s put some H₂O in there, then you got a science thing” (p. 117). Some of the students also viewed science as an activity that belongs to scientists and therefore not meant for them. Based on the findings of this study, the students perceived science, and particularly its language, as a different kind of language not easily encountered in everyday contexts. This perception is likely to have implications for students’ engagement and participation in science where some students may fail to embrace science simply because they cannot relate with its language. This may be the case even more for SLSL2 because they are not only learning science and the language of science but also the language of instruction (Brown & Ryoo, 2008; Rollnick, 2000). Indeed Gibbons (2002) argued that concepts students are learning in school may be new to all students but those learning in their first language are doing so in a familiar language and therefore “building on the foundations of their first language” (p. 5). This means that learning in a first language provides students with an anchor or hook for relating with new ideas.

To determine the exact nature of challenges that face SLSL2, Shaw, Bunch, and Geaney (2010) examined performance assessment tasks in science. Utilizing the textual and content analysis framework Shaw et al. analyzed written performance assessment tasks for fifth graders. Through the tasks, the students were expected to demonstrate not only their understanding but also their proficiency in their inquiry skills in three areas, namely relationships in an ecosystem, selection of appropriate snacks for a space ship, and determination of the level of contamination in a local stream. Shaw et al. found that there was a wide range of language demands in the tasks facing not just the ELLs but also those who are native speakers of English. According to Shaw et
al., the tasks required the students to have abilities of not only interacting with the teacher and peers, but also producing and presenting texts in prescribed genres. Based on the findings of this study, performance assessment tasks are likely to place linguistic demands on SLSL2 beyond their reach. What does the actual classroom learning of science in a second language look like? In the following section, I present a review of literature on science learning in a second language.

**Science learning in a second language.** A number of scholars have conducted research involving SLSL2 and have specifically examined classroom communication patterns and interactions between the teachers and their students, and among students themselves (Brock-Utne, 2007; Cleghorn, 1992; Duran et al., 1998; Kembo & Ogechi, 2009; Luykx et al., 2008; Moje et al., 2001; Westby et al., 1999). One conclusion common to these studies is that the students involved did not learn science in meaningful ways as was evident from the behaviors exhibited by these students such as silence, confusion and non-participation, bafflement, and mimicking of the teachers’ and peers’ speech and actions. For example, Duran et al. (1998) investigated how the cognitive and linguistic tools of students helped them in negotiating meaning in a biology class. Duran et al. conducted this study with 14 tenth grade students whose first language was Spanish and their teacher. The students were enrolled in a weekend program intended for enhancing their understanding of ideas learned in school. Data were collected through lesson observation, student questionnaires, students’ discussions, students’ written work, and interviews with the students. Duran et al. found that the students wrote or copied verbatim the teacher’s writing and talk. They had difficulties communicating scientific ideas and often gave chorus answers to questions. In addition, they did not view diagrams or tables as being important in learning science. However, when the teaching was structured to help the students view tools such as diagrams, tables and language patterns as being helpful in communicating
scientific ideas not only among themselves but also with the teacher, the students showed
dramatic improvement in terms of talking and writing science. Restructuring teaching involved
students working collaboratively to produce the diagrams that enabled them to communicate
their understandings. This study illustrates that although SLSL2 may exhibit behaviors that seem
to indicate they may not be learning science in meaningful ways, such students can be moved to
higher levels of learning where they are likely to view and use “cultural tools” (i.e., diagrams,
tables and language patterns) of science to interpret and communicate their understanding in
science.

In another study, Luykx et al. (2008) examined communication patterns among students
and their teachers in science. The study involved 23 third and fourth graders in a school that
served mainly Hispanic students (94% of the student population). Data were collected through
classroom observation of two class sessions taught by a monolingual, English-speaking teacher.
In one of the sessions, a bilingual Spanish-English co-teacher concurrently translated the lesson
content while in the other there was no co-teacher. Luykx et al. found that not much meaningful
learning occurred in the two classes and more so in the class where the Spanish-English co-
teacher conducted concurrent translation of the lesson content. This is because, as Luykx et al.
noted, the students in the class with the co-teacher sat and waited for the translation to take place
with minimal interactions between them and the teacher and between themselves. They also
noted that the co-teacher experienced difficulties in translating lesson content evident from the
long pauses between words and in some cases she provided a wrong translation of the lesson
content, which ended up distorting the intended meanings of the lesson content. On the other
hand, the few students who were proficient in English translated the lesson content in the class
without a co-teacher. As a result, they engaged each other as they negotiated meanings of ideas
in science both in Spanish and English and attempted to incorporate their teacher in their discussions. Even then, there was occasional breakdown in communication between the teacher and the students because the teacher did not understand Spanish and had to rely on a few students for translation.

This study shows that if meaningful science learning is to take place then there is more to consider beyond the language of science being different from the language used in everyday conversations. For example, the need for both the teacher and the students to understand each other is important but more important is the need for students to relate to not just what is being taught but also to make meaningful contributions during science lessons. This point is illustrated well by Brock-Utne (2007), who explored communication patterns in classrooms where the same content was taught through two different languages with one of the languages (Kiswahili) being considered as the home language of the students. The study, which was conducted in Tanzania, involved Form One (ninth grade) students divided into two groups (experimental and control). The students in the experimental group were taught biology and geography concepts in Kiswahili. The same concepts were taught to students in a control group in English. Of the four lessons reported in the study, two of them in biology, involving concepts and ideas on classification of organisms in the animal kingdom, were taught by the same teacher to both groups of students. The other two lessons, both on ideas in geography, were taught to the two groups by two different teachers. The researcher collected data through lesson observation of the classes in the two subjects. Brock-Utne found that there were minimum interactions between the teacher and the students and between the students themselves in the control group classes for both geography and biology. In these classes, the teachers talked most of the time and the students talked only when asked to answer questions for which most of them did not know the
answers. On the other hand, classes that were taught the same concepts in Kiswahili were more lively with the teachers having a difficult time in choosing the students to answer questions because of what Brock-Utne described as a “forest of waving hands” (p. 494) going up whenever a question was posed. Brock-Utne argued that there was more meaningful learning in the classes taught in Kiswahili than in those taught in English because students brought to the class their experiences with phenomena involving the concepts being taught and on which the teacher built new information and introduced new terminology. This means that students’ first language is a valuable tool for engagement and participation in science for SLSL2. In the following section, I review literature on everyday language and students’ language in science learning.

**Everyday language and students’ first language in science learning.** Everyday language and its influences on students’ understanding in science has been documented (McNeill, 2011). McNeill investigated how fifth graders’ ideas about science and scientists and their understanding of the words explanation and argumentation changed over the period of a school year. Working with fifth graders and their teacher, she collected data through student pre- and post-interviews, students’ writing and lesson observations as the students learned science ideas related to habitats. She found that, while the students’ ideas about science and scientists shifted and thus the students were able to write scientific argumentations over the period of a school year, their everyday meanings of the words explanation (i.e., an exchange between people) and argumentation (i.e., a disagreement) remained stable. The findings of this study show not just the influences of everyday language on understanding but also its stability over time and across different contexts. This implies that attention needs to be paid to students’ everyday understandings of ideas in science.
However, research has shown that students’ understanding and talk in science based on everyday language can shift to understanding and talking that draws on scientific language. This idea was revealed through a study conducted by Warren et al. (2001). Warren et al. described case studies involving two students, a Haitian sixth grader and a Latino fifth grader. The researchers interviewed the Haitian student following an analysis of video recordings of a discussion with his peers about metamorphosis of mealworms. They also observed the Latino student as he, together with peers, engaged in designing an experiment to determine whether ants preferred light or darkness and interviewed him together with two of his peers about their design. Warren et al. found that the two students who had started by using everyday language as they discussed about the scientific tasks at hand shifted with time in their thinking and talking to using more scientific ways of thinking and language use. According to Warren et al., this kind of shift was important because it helps the students in drawing a distinction between everyday language and scientific language. Warren et al. gave an example of such a distinction the Haitian student made between two important ideas in biology (i.e., growth and development) after his initial thinking and talking about them as change, a term in everyday language, “he began, during the whole-class discussion, by articulating an undifferentiated view of change, now he has these two aspects, central ones for biology, existing in some sort of defining contrast” (p. 538). According to Warren et al., this represents an important shift in the thinking and talking by the student – a shift from thinking and talking using everyday language (i.e., change) to that of thinking and using scientific language (i.e., growth and development).

Additionally, the first language particularly for SLSL2 has been shown to facilitate not only engagement and participation in science but also meaningful learning of science. For example, Ballenger (1997) described a study in which Haitian students spoke Haitian Creole and
brought their personal stories about not just how clean their bathrooms were but also how to clean and what materials to use in cleaning them as they talked about a science task – mold growth. Ballenger conducted this study with Haitian students from fifth through eighth grades in a multi-grade, bilingual classroom and three of their teachers. Following an analysis of video recordings of the students as they engaged in discussions of not only where but also how mold grows, Ballenger found that not only did the students participate in the discussions, they also raised questions that could be investigated scientifically. She observed of one student Joanne: “Science in schools often ends up with knowledge like, water is necessary for mold to grow. What Joanne is asking is how?” (p. 10). Joanne’s question seems to suggest that her curiosity had been raised as a result of engagement in the task of discussion about mold growth into wanting to know more about the processes involved in mold growth.

Similarly, Cleghorn (1992) investigated how students negotiated meaning in science through English and indigenous languages in Kenya. Cleghorn conducted the study in three primary schools where in two of them both students and teachers shared a common indigenous language, Kikuyu, while in the third school both the teachers and the students shared a different indigenous language, Dholuo. First, Cleghorn gathered data through classroom observation of lessons in the three schools from standard one to eight (first through eighth grades) in all of the subjects in the school curriculum that included English, science, home science, Kiswahili, and mathematics. This was followed by a more focused observation of only science teaching and learning at the same grade levels. She also interviewed science teachers whom she had observed teaching. Cleghorn found that in science lessons where the teachers did not adhere to the strict English-only language of instruction policy and instead code-switched between English and indigenous languages, there was better conceptual understanding of scientific concepts.
According to Cleghorn, both the teachers and the students were able to draw on their indigenous languages and bring their experiences to bear on the learning in science.

The question of whether or not learning in the students’ first language enhances conceptual understanding in science has been investigated (Prophet & Dow, 1994; Reinhard, 1996; Yip, Tsang & Cheung, 2003). While the findings of these studies are consistent in some aspects, they contradict in others. For example, Prophet and Dow (1994) and Yip et al. (2003) are consistent with regard to enhanced understanding and hence higher achievement in science by students who learned science in their first language. However, according to Prophet and Dow such achievement is not generalizable across grade levels. In their study conducted in Botswana, the Form One students who had been taught science in Setswana (the first language of the students) had better conceptual understanding of science concepts compared to not only their peers at the same grade level, who learned the same concepts in English, but also Form Three students who learned the same concepts in Setswana and in English. On the other hand, Reinhard (1996) found that there was no difference in achievement between the students who were taught science ideas in their first language and those who were taught the same ideas in a second language, but acknowledged that students who were taught science in their first language were livelier and participated more in class than those who learned the same concepts in a second language. While there may be need for further research before making conclusive statements with regard to enhancement in achievement in science when students learn in a second language, it is clear that there is more meaningful engagement and participation in science when students learn in their first language or when teachers draw on the students’ first language to leverage understanding in science. It seems then that with the students’ first language comes experiences they have acquired with scientific phenomena outside the classroom and therefore they can more
easily connect, relate and talk about them inside the classroom. The question of whether or not teachers have abilities to draw on students’ everyday ways of making sense of the world, including talking about scientific phenomena is a crucial one. In the following section, I present reviewed literature on teaching of science to SLSL2.

**Teaching Science to Students Learning in a Language other than their First Language**

Concerns have been raised with regard to the preparedness of teachers to teach students leaning in a language other than their first language (Janzen, 2008; Li & Zhang, 2004; Nieto, 2008). What is the status of teacher preparedness in teaching science to SLSL2? In this section, I present a review of literature involving teachers and the teaching of science. I have divided the review into three parts – research on professional development (PD) of science teachers, research involving pre-service teachers, and research involving teachers in the context of Africa.

**Research on professional development of science teachers.** Scholars have investigated in-service teachers and their teaching of science to SLSL2 (Fradd, Lee, Sutman, & Saxton, 2001; Lee, 2004; Stoddart, Pinal, Latzke, & Canaday, 2002). Fradd et al. (2001) investigated the influence of teaching ELLs with instructional materials that were congruent to the cultural and linguistic backgrounds of the students. This study, which was part of a multi-year project, involved a focus group of fourth graders from different linguistic backgrounds – bilingual Hispanic and Haitian and mainstream US English- and their bilingual teachers in four inner city-schools. Working with the teachers, the researchers developed materials on two instructional units – the water cycle and weather – consisting of ten and 15 lessons, respectively, requiring two to three hours of hands-on activities and discussion per lesson. They incorporated science terminologies in the students’ home language in the materials. They observed the implementation of the lessons with both the focus teachers and their students, and teachers and
students outside the focus groups. They also interviewed and assessed the students using paper and pencil science tests. They found that students in the focus group had higher achievement on the science tests than those in the non-focus groups.

In another study, Stoddart et al. (2002) investigated how the teachers’ thinking changed through involvement in a PD program. Stoddart et al. conducted the study with 24 teachers who had been participating in a Language Acquisition through Science Education in Rural Schools (LASERS) project. The project’s purpose was to prepare experienced teachers in teaching inquiry science to Latino students learning English as a second language. The researchers interviewed the teachers to determine their level of understanding and assessed changes in their reasoning and performance over time based on a 5-level rubric with level 1 revealing no evidence of either differentiation or integration of domains and level 5 revealing reasoning and viewing domains of science and language as being interrelated. They found that following science teachers’ involvement in the PD program, there was a shift in the teachers’ thinking to show that inquiry science and language acquisition are domains that could be integrated and taught together to enhance science learning for ELLs. Based on the findings of these studies, it is clear that PD programs play a crucial role in the enhancement of the teachers’ skills in teaching science to students whose first language is other than the language of instruction. In the following section, I present reviewed literature involving beginning science teachers and pre-service teachers.

**Research involving beginning and pre-service science teachers.** Like the case of in-service teachers, some scholars have conducted research involving beginning science teachers as well as pre-service teachers (Buck, Mast, Ehlers & Franklin, 2005; Gunning & Mensah, 2011; Howes, 2002). Buck et al. (2005) investigated the strategies a beginning teacher used to teach
science in a mainstream classroom having ELLs. The study involved a beginning teacher who was part of the research team and her class of 20 students, five of whom were ELLs. The researchers observed the teacher teaching science units on human biology, health, electricity, and magnetism. They also interviewed students (all the five ELLs and four non-ELLs) and examined students’ written work from their notebooks. The researchers found that the teacher experienced difficulties in implementing some strategies learned in teacher preparation and noted that there were gains in learning achievement by both ELLs and non-ELLs. However, there were differences in those gains with ELLs gaining minimally from the classroom interactions. Based on the findings of this study it seems then that strategies for teaching ELLs incorporated in pre-service teacher preparation programs may not be adequate to enable a teacher to enact teaching that is sensitive to the needs of ELLs. Much of the research involving pre-service teachers has tended to focus on their attitudes (Marbach-Ad, McGinnis and Dantley, 2008), development of self-efficacy and confidence in teaching science (Gunning and Mensah, 2011), and what the pre-service teachers bring to their training (Howes, 2002). Not much research has been conducted that focuses on pre-service teachers and the teaching of science to students learning in a language other than their first language.

Science teaching in the context of Africa. Not much research has been conducted in Africa targeting teachers and their science teaching. The little research literature that is available shows that science teaching is just as challenging for teachers as science learning is for students. This has been blamed in part on the teachers’ lack of competence in the language of instruction, which for most countries in Africa is a language other than the first language for both teachers and students (Evans & Cleghorn, 2010; Kembo & Ogechi, 2009). These studies have shown that meaningful science learning did not occur in the classrooms where the research was conducted.
and the students were left mostly confused. For example, Evans and Cleghorn (2010) investigated the teacher-student interactions in classes taught by student teachers in South Africa. Working with a group of six student teachers, the researchers collected data through lesson observation of the student teachers teaching various subjects in the school curriculum including science in grades R (preschool) through third grade. The researchers found that while there were some exemplary lessons conducted by the student teachers, there were also incidents where there were missed opportunities for students to learn in meaningful ways. According to the researchers, the missed opportunities occurred mainly due to miscommunication of science content to the students by the student teachers where the teachers used inappropriate terminologies. Evans and Cleghorn observed of one such incident:

The student teacher demonstrates to the grade Rs how a balloon is inflated by the gas created after combining bicarbonate of soda and vinegar (which she called opposites). She tells the learners ‘to look at the balloon blow up.’ The learners watch in keen expectation of an explosion. (p. 143)

According to the researchers, the balloon did not blow up, which left the students baffled.

While it may be argued that the teachers who participated in this study were still undergoing training and that is why there were missed opportunities for students to learn science in meaningful ways, elsewhere in Kenya a research study conducted by Kembo and Ogechi (2009) that involved trained teachers had similar findings. Kembo and Ogechi conducted classroom observations of several classes at primary school level for mathematics and science. In addition to the finding that the use of English as the language of instruction limited students’ access to meaningful learning of the content in the subjects observed, they also found that the
teaching due to inadequate mastery of English, the language of instruction. Kembo and Ogechi observed:

Teachers had difficulty explaining scientific and mathematical concepts simply and clearly because they lacked the appropriate lexical resources to facilitate this. This often led to code-switching to Kiswahili and other local languages, but with very little remedial/developmental consequences. In many cases even code-switching was inappropriately applied and led to even more confusion (p. ix)

While there may be need for more research targeting teachers and their teaching of science especially at the high school level, the findings of these studies may mean that access to meaningful science in the context of Africa has an added layer of complexity beyond the challenges related to science content, language of science and language of instruction being different from the students’ first language – that of teachers’ incompetence in the language of instruction.

**Chapter Summary**

This review of literature drew from three main bodies of research, namely, cultural knowledge and school learning, science learning and language, and teaching science to SLSL2. From the reviewed literature on cultural knowledge and school learning, we can see that a lot of research has been conducted that recognizes cultural knowledge as an important form of knowledge that exists outside the classrooms but one that can be drawn upon to leverage students’ learning in their classrooms. Areas of similarities and differences between cultural knowledge and scientific knowledge have been identified that include a similarity where the two forms of knowledge share some of the methods of knowledge construction (i.e., observation) and differences in methods of passing the knowledge to younger generations. However, areas of
similarities and differences between the two forms of knowledge with a focus on specific content areas have not been investigated, much less how students talk about the specific ideas involved in the content outside the classroom. Information from such an investigation would provide ideas on not only how, but also what teachers could draw on in helping students relate cultural knowledge and science learning thereby leading to enhanced learning in science. In addition, if science teachers are expected to be effective culture brokers (Aikenhead, 2001) then their awareness about cultural and talk students come with to the classroom is inevitable.

Also clear from the literature are ways of integrating cultural knowledge with school science, specifically drawing from the examples illustrated through studies conducted by Aikenhead (2001) and Kawagley et al. (1998) involving cultural knowledge of the Aborigines and Yupiaq communities, respectively. In the Kenyan context, some research has been conducted around cultural knowledge in which recommendations have been made with regard to the need for science teaching that is not only relevant to the lived experiences of the students but also one that helps students to be aware of cultural knowledge outside the classroom and its potential for use in solving real-life problems. However, it was unclear as to whether teachers were aware of students’ understandings of scientific phenomena outside the classroom and their abilities to draw on those understandings to leverage students’ science learning. Thus, this research did not only explore students’ cultural understanding of science outside- and inside-the-classroom contexts but also sought to determine the teachers’ awareness of the cultural knowledge students come with to class.

From the review of literature on science learning and language, it was clear that a lot of research has been undertaken involving SLSL2. From such research, it has been shown that SLSL2 experience challenges related to not only the content and language of science but also the
language of instruction being different from the students’ first language. Further research shows that these students can be made to gain meaningfully from the learning experiences in science if teachers draw on their everyday ways of making sense of the world to leverage them to higher levels of effective science learning. However, most of the scholars working with SLSL2 have tended to focus on classroom interactions and communication between the teachers and the students and between the students themselves. Not much attention has been directed towards students and their experiences with scientific phenomena outside the classroom and how that relates to their understanding of concepts involving the same phenomena. It was expected that SLSL2 encounter and experience scientific phenomena outside the classroom. It is possible that they talk about those phenomena with peers and family members and hence develop some understanding regarding those phenomena. It is also possible that as and when they do so, it happens in ways and in a language that makes the most sense to them – the everyday language. If students come to the science classroom with these ways and no attention is paid to them then their understanding of science may be hampered.

The reviewed literature on teaching science to SLSL2 reveals that some scholars have directed their attention towards teachers and their teaching of science to SLSL2. Most of the research has been done under the auspices of PD programs. It is clear that even though not much research has been conducted with pre-service teachers and what goes into their preparation to teach science to SLSL2, PD programs are crucial in enhancing teachers’ abilities in teaching science to SLSL2.

This review of literature revealed that a variety of methods were used in data collection in the studies reviewed. Classroom observation, questionnaires and interviews seemed to be the main methods of data collection employed by the researchers. Given the socio-cultural and
linguistic aspects of my research (i.e., how students talk about ideas inherent in phenomena they experience outside the classroom as well as learn about in the classroom), I chose focus group discussions as a strategy for data collection with the students. I reasoned that this strategy would allow students to draw on the socially shared tools (i.e., language and its use) both outside- and inside-the-classroom contexts in talking about ideas inherent in the phenomena investigated. I discuss details of the methods I adopted in this research in the next chapter.
Chapter Three – Methods

Introduction

In this chapter, I describe the methods I adopted for this research that include the research design, selection of research location, setting, and participants. In addition, I provide the data collection techniques and data analysis process. Lastly, I discuss some of the biases, barriers and opportunities in this research. I begin the chapter with a description of the research design.

Research Design

Through this research I sought to explore how secondary school students understand ideas inherent in physical science phenomena both outside- and inside-the-classroom contexts through their talk. The research involved selected students from one public, day, mixed gender secondary school from the Maragoli community of the Western region in Kenya. This research is therefore a case study. Through case studies researchers can explore in depth a program, event, activity, process, or one or more individuals (Creswell, 2009). Case studies employ a variety of data collection techniques that include observation, document analysis and interviewing (Bogdan & Biklen, 2007).

I collected data from the students through focus group discussions as they engaged in talking about ideas inherent in selected physical science phenomena. Focus group discussion is a strategy where a researcher engages a group of seven to ten participants in a discussion(s) for purposes of gaining varied perspectives on the issue being studied (Bogdan & Biklen, 2007). I employed focus group discussion strategy for this reason. That way I was able to gain insights into students’ understanding about ideas inherent in the phenomena and activities investigated. I also adopted this strategy for data collection from the students because I wanted to provide them with a forum where they could draw support and encouragement from each other as they
engaged in the discussion sessions. This was necessary given my understanding about learning as a social endeavor (Vygotsky, 1978). To supplement data from the students, I interviewed two of the students’ teachers. I also examined the syllabus for objectives, content, and level of content treatment, and the students’ examination papers for their responses to questions on teacher-made assessments regarding ideas investigated in this research as documents providing additional data. Documents are recognized as important sources of data in qualitative research (Bogdan & Biklen, 2007).

**Research Location and Setting**

This research was conducted in Ekilaka (pseudonym) Secondary School in Vihiga constituency, Vihiga County of the Western region in Kenya. It involved Form Two students and two of their teachers (one each for chemistry and physics). Vihiga County, one of the four counties in the Western region of Kenya is composed of five constituencies. The constituencies are: Hamisi, whose residents speak Kitiriki; Emuhaya and Luanda, whose residents speak Kinyore and Vihiga and Sabatia, whose residents speak Kimaragoli. These languages are only three of the 18 dialects of Kiluhya, which is the dominant language in the Western region. Figure 2 shows Vihiga County and its constituencies. In choosing Vihiga constituency as the place to conduct this research I was guided by the need to have a site that could enable me draw on my “insider identity” (Ryen, 2003) to propel the research agenda and process. I was born and raised in Emuhaya constituency and married in Vihiga constituency and therefore can speak both Kinyore and Kimaragoli dialects with relative ease. I am also fluent in Kiswahili.
In seeking to understand how students talk about the selected physical science phenomena, I had anticipated that the students would draw on their community language to talk about the phenomena in question, particularly with regard to the outside-the-classroom context. The ability to speak Kimaragoli was therefore a resource for me in not only being able to communicate with the students but also understand them as and whenever they used the language. Scholars who undertake qualitative research recognize that the researcher’s personal qualities, and attitudes of mind such as assumptions, views and beliefs may impact all or some of the aspects of the research process that include problem conceptualization, data collection and analysis, and reporting in unpredictable ways. For example, Peshkin (1988) observes that such qualities could “filter, skew, shape, block, transform, construe, and misconstrue what transpires
in a research project” (p. 17). Remaining reflexive throughout the research process is therefore a necessary aspect of qualitative research (Frisoli, 2010).

I, as the key instrument (Creswell, 2009) in this research, was aware that my ability to speak the same language as the students could be counterproductive to this research. For example, my knowledge that some of the words as used in Kimaragoli and Kinyore about scientific phenomena may mean different things in English could easily have made me want to impose my own meanings and understandings to students’ words and ideas as they talked about the scientific phenomena investigated in this research. For this reason, I paid special attention to the students’ words and ideas and sought their clarification to be sure that the meanings I was portraying were those of students and not mine. As a strategy of validating the data, I took time to highlight key words and phrases arising from preceding discussions with students and asked them to clarify that they were representative of what they meant when they used those words and phrases during the discussion sessions that followed. I also enlisted the assistance of a secondary school Kiswahili teacher from the same community but not from the same school, to help in confirming the accuracy of my translations from Kimaragoli and Kiswahili to English to avoid misinterpreting the students’ words and conversations.

Vihiga constituency occupies an area of approximately 90 square kilometers (35 square miles) with a fairly good portion of it being rocky. It has a population of approximately 90,000 people (KNBS, n.d.). It is considered a constituency in rural Kenya because it lacks major towns. Indeed, there is only one small town, Mbale, which serves as the headquarters of the whole County. But there are many market places within the constituency where people go to buy and sell their farm produce. Just like other rural places in Kenya, most of the people in Vihiga constituency are subsistence farmers relying mainly on growing food crops such as maize (corn),
bananas, sweet potatoes, cassava, vegetables, and animal husbandry which involves keeping animals such as cows, goats and chicken, for their survival. The road network in Vihiga constituency is poor with only one road paved, the one joining Vihiga, the administrative headquarter to Mbale town and other towns beyond the County. The rest of the roads within the constituency are unpaved. This makes transportation of people and goods off the paved road difficult because the owners of public transport vehicles are afraid of putting their vehicles on such roads due to high maintenance costs. Therefore, people walk long distances to their destinations and others who can afford rely on motorbikes for rides at a fee. Besides the earth roads within the constituency, there are several footpaths that crisscross the entire constituency such that visits to neighbors, friends and to an extent relatives are made possible through the use of such footpaths. Such footpaths are also useful when people go out in search of firewood and collection of water from springs. Appendix D shows pictures of parts of Vihiga constituency, especially the rocky area, earth road and a footpath joining homesteads.

It is not just the road network in Vihiga constituency that is poor; the majority of the residents do not have access to other amenities such as piped water and electricity. Electricity is available mainly in market places, some schools and to individuals who can afford not only the installation fee but also the monthly bills. Thus, the majority of residents in Vihiga constituency rely on firewood for cooking and kerosene lamps for lighting their homes. With regard to water, the majority of the residents rely on water from rain or springs. The rainwater is usually harvested using gutters constructed along the edges of the corrugated iron roofing commonly found in homes. Some people use large tanks for storage of the water while others who cannot afford the tanks, just collect the water in small containers as and whenever it rains and therefore the water may not last for a long time. In that case then such people rely on springs for their
water needs. The spring water is soft (it forms lather easily with soap) and therefore does not contain dissolved substances that could render it hard (making it difficult to form lather with soap). People fetch the water from the springs using jerry cans. They are generally advised to boil the water before using it for drinking to avoid water-borne diseases such as typhoid.

As at the time of collecting data for this research, there were 21 secondary schools, one of which is private, in Vihiga constituency. Of the remaining 20 schools, 16 are mixed day or day and boarding schools. Ekilaka, which I selected (through the process I have explained below) from among the 16 mixed day and day and boarding schools, has been in operation since the mid-1990s. It is a public, day, mixed gender secondary. It had a student population of approximately 200 students with the ratio of the number of boys to girls being approximately 1:1. I chose a public school because the MoE has control over the curriculum emphasized in this category of schools. Therefore, one can predict with some level of certainty what the students have learned or are likely to be learning at a given point in time based on the syllabus booklet. I chose to conduct this research in a day school because the likelihood of getting students who spoke the same community language was higher. This is because students in such schools commute to and from school every day, meaning that they live within the community in which the school is located. It was important for students to speak the same community language for this research since it would allow for students to communicate with one another with ease, especially if they used Kimaragoli during the discussion for the outside-the-classroom context. For the same reason, it would also allow me to understand them.

The office of the District Education Officer (DEO) (the education official in charge of education at the district level) for Vihiga district was instrumental in helping me select the

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5 These are containers with an opening of 2½ - 3 inches in diameter at the top. They are mostly made of plastic and have a capacity of 20 liters.
research school. One of the requirements of the National Council for Science and Technology (NCST), the institution charged with the responsibility of research approval in Kenya, was that I pay courtesy calls to the District Commissioner (DC) and the DEO for Vihiga District before embarking on this research. I, therefore, started by visiting the County Commissioner (CC), Vihiga County Mr. Joseph Kanyiri given that he is the overall person in-charge on all matters including education in the county. It was also because his office and those of the DC and DEO for Vihiga district were in the same building. After signing the visitors’ book, I informed him of the purpose of my visit – conducting research in one of the schools in the County. I presented him with a copy of the research authorization letter from NCST which he read. He informed me that it was fine for me to conduct the research in the county. He also informed me that he was going to make the office of the DC aware of my presence in Vihiga district as a researcher and therefore it was not necessary for me to visit the DC’s office. Furthermore, he informed me that the DC was away attending a workshop outside the County. With this assurance about my presence in the district from the CC, I moved to the DEO’s office where I met Mr. Wilson Amolo, the District Quality Assurance and Standards Officer (DQASO) who is charged with the responsibility involving matters that regard research in the district. Just like I had done with the CC, I presented the DQASO with a copy of the research authorization letter that he read and said that it was fine for me to conduct my research in the district. With the help of the DQASO, I learned that the school I had initially selected to conduct this research based on the list of schools from the MoE did not have teachers employed by the teachers’ service commission (TSC) in physics and chemistry.

The TSC is the body charged with the responsibility of employment of teachers in Kenya. From the records in the DQASO’s office, the teachers teaching physics and chemistry in the
school were unqualified. Teacher training is a factor that could influence not only how teachers perceive but also conduct their teaching. There and then in the DQASO’s office I selected Ekilaka secondary school as my next choice. The DQASO checked the teacher training status and found that there were two trained teachers for chemistry and no trained teacher for physics in the school. I decided to go on with the research in Ekilaka even though the physics teacher was unqualified. This was because of my knowledge of the teacher shortage in some schools in the country arising in part on the policy on teacher recruitment (TSC, 2006). The policy requires that schools identify vacancies, inform the TSC which then advertises for the posts. Then the schools’ Board of Governors (BOGs) interview qualified teachers and send the list of successful candidates to the TSC which then writes the appointment letters. As this process is ongoing, students are often left without teachers. To mitigate the problem, BOGs employ teachers, who are in most cases unqualified, to teach the students. Based on this therefore, going on with the exercise of selecting and checking the training status of the teachers in the schools was unlikely to yield results that matched my criteria of a public, day, and mixed gender secondary school as the research school. In addition, I thought it would be interesting to compare the views of the teachers on teaching ideas investigated in this research based on whether or not the teacher was trained. Thus, Ekilaka Secondary School became a perfect site for that.

Participants

Seven students and two teachers participated in this research. The students, three boys – Matini, Matayo and Yohana – and four girls – Muhonja, Kayali, Aliviza and Imali were all in Form Two and were aged between 16 and 18. They all came from the community in which the

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6 An unqualified teacher in Kenya is someone who is not trained as a teacher and therefore does not hold a professional qualification to become a teacher. Such a teacher may hold a degree in a content area or may be fresh from school without any learning beyond the high school level. A professional qualification may be a certificate such as one held by the majority of teachers at the primary school level or diploma or degree such as one held by the majority of teachers at the secondary school level.
school is located and therefore spoke the same community language, Kimaragoli. They also spoke Kiswahili, which serves as a national language. To protect the identities of the students all the names are pseudonyms. The teachers who participated in this research are Evelyn, the chemistry teacher and Chris, the physics teacher. Just like the students, the teachers’ names are pseudonyms to protect their identity.

After selecting Ekilaka secondary school in the DQASO’s office to conduct this research I visited the school, which is approximately 12 to 15 kilometers from the District headquarters where I had been paying courtesy calls to the CC and DEO. The purpose of this initial visit to the school was to meet the principal and request that I conduct research in his school. Upon arrival and after introductions conducted in the principal’s office, I gave the principal a copy of research authorization letter and explained that the purpose of my visit to the school was to conduct research in the school. His main concern about the research was how I was going to protect the identity of the school given that it was the only school involved in this research. He explained that even though it had not happened to his school he had seen and heard about researchers who portrayed schools in which they conducted their research in a bad light and therefore he did not want the same to happen to his school. I explained that I would use pseudonyms for both the school and participants (i.e., the students and the teachers) to make it difficult for the school, together with teachers and students, to be linked to the report arising from this research. With this assurance, the principal introduced me to Evelyn and Chris as the teachers who would not only participate but also with whom I was to work in selecting the students to participate in the research. Ekilaka had two chemistry teachers and one physics teacher. As explained earlier about the process of selection of the school to conduct this research, both the two teachers of chemistry were qualified while the physics teacher was unqualified. I chose to work with Evelyn, the
chemistry teacher because even though she was not teaching chemistry to the current Form Two (tenth grade) students, she had taught them chemistry when they were in Form One (ninth grade). I reasoned that incase I needed to seek clarification on any issues pertaining to the learning of chemistry ideas as learned in Form One (ninth grade), then the teacher who would be in a better position to respond was Evelyn. I had no choice to make for the physics teacher to involve in this research because Chris, the physics teacher was the only one in the whole school.

I started by explaining what the research was about to the two teachers and requested for their consent to participate in this research, which they gave by signing the written consent forms. The teachers then helped in selecting eight students to participate in this research. The students were selected based on the criteria of equal number of girls as boys. In addition, we considered the academic abilities of the students which included above average of which there were two girls and one boy, average of which there were one boy and one girl, and below average of which there were two boys and one girl.

Being a day school, all students selected walked to school every day taking varied times with the nearest to school taking five minutes and the furthest 1 hour 20 minutes. With the help of the teachers, I arranged a meeting with students where I explained what the research was about and requested them to participate. They all agreed and for those who were younger than 18 years, I gave them assent forms to sign to show their willingness to participate in the research. I also gave them consent forms to take to their parents and asked them to explain what the research was about to their parents and request them on my behalf to sign the forms and return them to me the following day, which they all did. To those who were 18, I gave them consent forms, which they signed also to show their willingness to participate in the research. The student who took the longest to arrive in school eventually opted out from the research citing
distance as the reason, but later I learned that he was involved in playing soccer in the school team. Since tournaments were held on Saturdays (the days initially scheduled for discussion sessions), rather than miss playing in the school team he preferred to miss discussion sessions involving this research.

**Data Collection**

The main data for this research were focus group discussions with the students. But I also interviewed one chemistry teacher and one physics teacher to get a sense from them on how they not only viewed the teaching but also described their own teaching of ideas involving phenomena investigated in this research. In addition, I examined the syllabus for objectives, content and level of treatment of content involving ideas investigated in this research. Lastly, I examined the students’ responses to questions involving ideas investigated in this research on teacher-made assessments. These additional sources of data were particularly useful in helping me understand the reasons likely to be behind how students talked about ideas inherent in the phenomena investigated. In the following sections, I describe the process of data collection for each of these data sources starting with focus group discussions.

**Focus group discussions.** I conducted the focus group discussions in the school but outside the students’ class time. All the sessions were conducted in the school laboratory, the room assigned to me by the school. I had planned to conduct the discussions on Saturdays and actually did it for the first two sessions. But, through Chris, I learned that there were co-curricular activities (e.g., sports and symposia) that were to take place mostly on Saturdays and that some of the students involved in this research would be participating. To minimize students’ absences during the focus group discussions, I rescheduled the remaining sessions to Fridays.
after classes (i.e., between 4:00 and 5:30 pm). The discussions were conducted for both the outside- and inside-the-classroom contexts.

For the outside-the-classroom context, the discussions were preceded by students watching short videos (one to two minutes long) and pictures of the phenomena investigated in this research. The phenomena are those that involve ideas in chemistry on dissolving, evaporation and condensation and those that involve ideas in physics on static electricity and electric current. They included the following phenomena and activities: steam rising on a tarmac or paved road following rain on a hot day, water vapor formation from cooking food, dew on grass, salt addition to food, thunder and lightning, static cling, and electric current. The videos on the phenomena investigated in this research are available at [http://www.youtube.com/channel/UCKaQratqVqvoI6KHZ7Uqbnw](http://www.youtube.com/channel/UCKaQratqVqvoI6KHZ7Uqbnw). See also Appendix C for the pictures used in this research. I used a total of six videos numbered 2 through 7 and two pictures numbered 3 and 4 to collect data for this research. I shot all the videos shown at the URL except videos #3 and #6. I obtained these two videos from online sources and edited them to capture only the sections showing the phenomena to be discussed. I also obtained all the pictures used in this research from online sources.

I was guided by the syllabus (KIE, 2002) in selecting these phenomena since the phenomena had to be those experienced by students in their everyday lives as well as those studied in their school science. Ideas involving these phenomena are learned in Form One. Therefore at the Form Two level, I anticipated that students would be in a position to talk about the ideas as learned in the science classroom. In selecting these phenomena I also considered the need to be able to conduct hands-on-activities about them as would be done in the science classroom. Thus, the need for ideas to be in the syllabus was a necessary but not sufficient
criterion for their selection. The students watched the videos and looked at the pictures on my laptop, which was placed in a strategic position for all of them to have a clear view. To maintain consistency in talking about the videos, we assigned the name Petronila to the person in videos #2, #5 and #7 doing the cooking and charging the phone. The purpose of the videos and pictures was to cue the students to vicariously experience the phenomena and as such enable the students to talk about ideas the inherent without having me describe them. After watching the videos and looking at the pictures in a given session, I asked the students to talk about what they had observed happening in the video or seen in the picture and why they thought things happened that way.

For the inside-the-classroom context, the discussions were preceded by demonstrations of hands-on-activities conducted by me on concepts and ideas inherent in the phenomena investigated in this research. In the demonstrations, I used apparatus and materials as would have been used in the science classroom to teach those ideas. Key questions that guided the discussions in the inside-the-classroom context as was the case with the outside-the-classroom context, were with regard to what the students had observed happen in the demonstrations and why they thought things happened as observed.

Building rapport with participants is an important step, especially in qualitative research given the prolonged periods of time spent with them (Taylor & Bogdan, 1998). As such, prior to collecting data I arranged for two meetings of approximately 30 minutes each on different days to familiarize myself with the students and specifically to know their names. I also used this opportunity to conduct a trial focus group discussion using video #1 and pictures #1 and #2 as topics for the discussions. I also used the trial focus group discussion time not only to check on the positioning of the equipment (i.e., laptop, camera and voice recorder) but also as a way of
getting the students to interact and talk with each other in front of me and the camera. On watching the video recording of the trial focus group discussions I noted that there was glare arising from too much light getting into the laboratory leading to blurry images of the students. As such I minimized this glare by covering the windows with curtains during the actual data collection.

It is also during the familiarization visits that we settled for Kiswahili as the language of discussion for the outside-the-classroom context. I had asked the students to use Kimaragoli, their first language to talk about ideas inherent in the phenomena investigated outside-the-classroom context but they said that they were not comfortable speaking Kimaragoli. They said that they preferred to use Kiswahili instead. The idea of not feeling comfortable to speak Kimaragoli might be due to the influence of using English as the language of instruction and the fact that some schools insist on students speaking English in school. Therefore, these being discussions conducted in school may have led to students’ thinking that it would be against the school regulation to speak Kimaragoli in school. I allowed the students to use Kiswahili given my understanding about language as a tool for enhancing human communication and understanding (Shatz & Wilkinson, 2010; Vygotsky, 1978) rather than a hindrance.

Additionally, while Kiswahili may not be considered the students’ first language in Kenya, its status as a national language has enabled the general population of people in Kenya to develop proficiency in most of the aspects of the language that include writing, speaking and reading. Thus, in a sense Kiswahili could easily be considered to hold the same status as the first language for a majority of the population of people in Kenya. However, the idea that students preferred to use Kiswahili rather than Kimaragoli made me wonder whether there was more to it other than the venue of the discussion being school. In other words, had I chosen to conduct this
research with students at a venue other the school (i.e., church compound, my home or any of the students’ home), would the students have agreed to use Kimaragoli? And would the results have replicated? These are questions that certainly require further inquiry and those that can help inform policy in terms of language of instruction. In order for the inside-the-classroom discussions to mimic the school science classroom I asked the students to use English, the language of instruction in talking about phenomena as observed in the demonstrations. However, the students occasionally switched to Kiswahili on their own and sometimes on my request, as I sought to compare words used in describing phenomena across the three languages – Kimaragoli, Kiswahili and English.

I conducted a total of six focus group discussion sessions with an average of 41 minutes of discussion time per session. The discussion on dissolving for both the outside- and inside-the-classroom contexts was the shortest with a discussion time of 26 minutes while that on static electricity was the longest with 58 minutes of discussion time. While I was able to conduct both the outside- and the inside-the-classroom discussions for some ideas in one session (in particular, dissolving, and static electricity), it became difficult to accomplish it for others. This was mainly because of the many cues (i.e., videos of the steam rising on the road, water in a sufuria\textsuperscript{7} over fire covered and uncovered, and picture of dew on grass) for the evaporation and condensation ideas in an outside-the-classroom context. Also as was the case with electric current, the session was interrupted by rain pounding hard on the iron roofing that made it difficult to hear what was being said.

Initially, the students were shy and unable to engage each other in discussions about what they had observed in the videos, pictures and demonstrations. It happened that one student would

\textsuperscript{7} A flat based, deep sided, lipped and handle-less cooking utensil usually made from aluminum. It can be bought with or without a cover, which is also flat, circular, handle-less and made of aluminum.
begin the conversation but then none of the other students would be willing to join in. This may have been due to my presence as a person new to them. It could also have been because the students may not have been familiar with a forum where they were required to discuss ideas with each other. As such the earlier discussions sessions (especially the first three) were full of interjections by me not only urging the students to continue talking but also asking for their clarifications of their ideas that were unclear.

I recorded the students’ discussion sessions both on video and audio recorders. I placed the audio recorder on the table where the students sat while the video camera was approximately three meters away. For this reason, the sound quality and clarity on the audio recorder was much better than that of the video. I therefore relied mainly on the audio recorder in transcribing the students’ discussions. However, the video was useful in helping me to recall aspects of the discussion sessions that were not captured in the audio recorder (e.g., demeanor, gestures, facial expressions, students’ reactions to one another). Immediately following each discussion session I transcribed the audio recordings and identified areas I needed to seek further clarification from the students during the next discussion.

**The teachers’ interviews.** I interviewed one chemistry teacher and one physics teacher. This was done to gain insights into how the teachers not only viewed but also described the teaching of ideas inherent in the phenomena investigated in this research. The chemistry teacher, Evelyn, is a female likely to be in her late 20s or early 30s. She is a qualified teacher of biology and chemistry and had a teaching experience of two years. As mentioned, Evelyn taught chemistry to the current Form Two students when they were in Form One. However, at the time of the research, the students were being taught chemistry by another teacher. On the other hand, Chris, a male most likely in his mid-20s is an unqualified teacher. Although he had not taught the
current Form Two students when they were in Form One, he was their current physics teacher given that he was the only physics teacher in the school. Just like Evelyn, Chris had a teaching experience of two years. He taught physics to Form One and Two students and at another school for one year before joining Ekilaka.

Upon securing their consent to participate in this research, I arranged with the teachers for one-on-one interviews on days and times that were convenient for them. These were days they did not expect to be in class and soon after I conducted focus group discussions with the students on the respective chemistry and physics ideas. In addition to asking the teachers for their background information, such as the teaching subjects, experience, and professional qualifications I asked them to talk about their experiences in preparing to teach, teaching and assessing ideas inherent in the phenomena investigated in this research (see Appendix B for the teachers’ semi-structured interview protocol). The interview with Evelyn lasted 17 minutes while the one with Chris lasted 31 minutes. I audio recorded the interviews and transcribed the audio files soon after in readiness for data analysis.

**The secondary school science syllabus.** The secondary school science syllabus is another source of data for this research. As mentioned in Chapter One, the syllabus is an important document in the Kenyan education system. It is centrally developed by the Kenya Institute of Curriculum Development (KICD), formally the Kenya Institute of Education (KIE), for all the subjects in the school curriculum at the primary and secondary levels. It is used as a guide by teachers in terms of providing objectives and content to be covered for a given topic. It also provides a guide for teachers in terms of time (weeks) to be taken to cover the content. I examined the syllabus for objectives, content and level of treatment of the content on topics involving the phenomena investigated in this research. I also sought to determine efforts in the
syllabus, if any, that were directed towards linking ideas in science to students’ everyday experiences.

**Teacher-made student assessments.** Lastly, I examined students’ responses to questions on ideas investigated in this research from teachers-made assessments. As mentioned in Chapter One, students at the secondary school level take the KCSE at the end of their four year course. KCSE is a national examination that determines whether or not students continue with higher education. However, during and at the end of each school year students are assessed on their understanding of content through teacher-made assessments. Such assessments are intended to help the teacher in determining the level of students’ understanding on content that has been covered by the teacher. The teacher marks (grades) the students’ work and returns the papers to the students who are expected to keep the papers in a folder or file and use them for revision for future examinations, including the KCSE. In Ekilaka Secondary School, students received three teacher-made assessments referred to as cycle I, cycle II and end term in each term of the school year. The assessments were approximately one month apart.

I had requested the students that I use their question papers for teacher-made assessments in Form One as one of the sources of data for this research and they had all agreed. For chemistry, the highest number of examination papers I was able to obtain was from six out of the seven participants for an examination done for cycle II in the second term of their Form One course. This was not, however, the case with physics, where the highest number of papers available was from three out of the seven participants. I therefore asked the physics teacher to include some questions on ideas involving phenomena investigated on the cycle II examination of the term in which I conducted this research. This way I was able to obtain responses to

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8 A school year in Kenya is divided into three terms 1st, 2nd and 3rd of three months each starting in January. The terms are separated by three school holidays of approximately one month each.
questions of interest from all the seven participants. I made copies of the students’ papers both for the chemistry and physics examination and returned the papers to the students. In examining the students’ responses, I sought their understanding of the ideas involved in the phenomena investigated through their responses. I was specifically interested in the words used to describe and explain their ideas on questions about phenomena investigated. Table 6 shows a summary of data for this research and their sources.

Table 6: Summary of data types, sources and methods of collection

<table>
<thead>
<tr>
<th>Method used to obtain the data</th>
<th>Participants/source</th>
<th>Type of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus group discussions</td>
<td>Selected Form Two students</td>
<td>Video transcripts</td>
</tr>
<tr>
<td>Interviews</td>
<td>Chemistry and physics teachers</td>
<td>Audio transcripts</td>
</tr>
<tr>
<td>Document collection</td>
<td>Students’ Form one chemistry and physics examination papers</td>
<td>Written responses to questions about phenomena investigated</td>
</tr>
<tr>
<td></td>
<td>The secondary school syllabus</td>
<td>Objectives and contents for topics involving phenomena investigated</td>
</tr>
</tbody>
</table>

Data Analysis and Writing

In this section, I describe the data analysis procedures as well as decisions I made in writing the findings. I begin with the data analysis procedures. This is followed by writing about the findings.

Data analysis procedures. The main data for this study were transcripts of the focus group discussions with the students. Before I describe the data analysis process, I clarify that I selected the students who participated in this research based both on academic abilities and gender balance. The intention of doing so was to have a sample of participants who were representative of the school’s student population. As mentioned, Ekilaka had a student
population of approximately 200 students with the ratio of boys to girls being close to 1:1. Also, students in a given school are often ranked based on their performance on teacher-made students’ assessments. I anticipated that Ekilaka was no exception in this regard. Thus, while I considered gender balance and academic abilities in selecting the students, I did not consider these factors in analyzing the students’ talk about ideas investigated. This is because such analysis would have jeopardized the identities of the students which I had promised to protect as per the Institutional Review Board (IRB) guidelines. I reasoned that since teachers were involved in the selection of the students, they had ideas about which students were in the different categories. Thus analyzing the students’ conversations based on academic abilities would make any of the teachers involved in the student selection process to identify the students if s/he came across this dissertation. Similarly, I did not conduct analysis of students’ conversations based on their gender. This is because as you may notice in the reporting of the findings, I did not observe differences in their contributions to the discussions based on gender.

Before embarking on the process of data analysis I read and re-read the focus group discussion transcripts and cleaned them by omitting words or phrases and unnecessary repetitions that would otherwise make it difficult to follow the conversations (Luttrell, 2003). I then started the process of data analysis by assigning codes to students’ conversations based on whether their understanding and talking about the ideas inherent in the phenomena and activities investigated was drawing on everyday ways of making sense of the world – language, manipulations and observations or scientific ways – those that utilized scientific terminologies and explanations. My choice of these codes was guided by Aikenhead and Jegede’s (1999) idea of border crossing. Aikenhead and Jegede believe that students come to class with ways of understanding the way the world works influenced by their everyday culture that may be
different from those of the culture of the science classroom. I imagined that given that the
language of instruction is different from that spoken by students especially from rural Kenya, the
students might talk about scientific phenomena experienced in their everyday lives in ways
including a language similar to that used in their everyday conversations. I used the code
*everyday ways* to code these ways. The meaning I attached to the students’ talk coded *everyday
ways* was that the students were yet to cross the cultural border into the culture of the science
classroom. Thus, for any students whose talk I coded *everyday ways*, I viewed such students as
belonging to group X as per figure 1. In other words, such students were operating in their
everyday culture.

Within the code, *everyday ways* were sub codes that include *everyday language, everyday
observations, experience* and *cultural knowledge*. *Everyday language* did not necessarily have to
be Kimaragoli or Kiswahili. The main idea behind *everyday language* was that it lacked
scientific terminologies or if such terminologies were present, then they were used in their
everyday sense. An example of such a word is energy, which is defined as the ability to do
work, in science but the word energy is also used to refer to electricity or gas in everyday
conversations. *Everyday language* also included words or phrases in Kiswahili or Kimaragoli
that meant different things in English, the language of instruction. An example of such a word is
*moshi* (Kiswahili for smoke). Students used this word to refer to water vapor formed when water
boils or formed on roads and rocks following rain on a hot day.

With regard to *everyday observations*, I assigned this code to students’ conversations
where they explained their understanding about the ideas in the phenomena investigated based
on superficial mostly visual characteristics or features. I borrowed this label from Eberbach and
Crowley (2009) who define *everyday observations* as “those that occur with little or no
knowledge of the constraints and practices of scientific disciplines” (p. 46). This means that an everyday observation may not help a person to make connections that lead to a deeper understanding of the phenomenon being observed. Experience, on the other hand, is a code I assigned to students’ conversations that depicted them as actors or witnesses of actions or ideas being talked about. The last sub code under everyday ways is cultural knowledge, which I assigned to students’ conversations that included their talk about ideas in the phenomena investigated from sources other than themselves. Such conversations were characterized by statements that began with “I am told that . . .” or “It is said that . . .” While the rest of the codes were evident across all the six discussion sessions, cultural knowledge was evident in only a section of the session on static electricity, specifically thunder and lightning. Besides everyday ways, I adopted the code scientific language and assigned it to students’ conversations about the ideas investigated that drew mainly on scientific terminologies and explanations. My interpretation with regard to students’ conversations coded scientific language was that the students were able to draw on tools (i.e., scientific language) from the culture of the science classroom to talk about ideas inherent in the phenomena investigated. However, I was careful not to jump to conclusions based on a given conversation that the students involved had crossed the cultural border as per figure 1 and thus belonged to either group Y or Z. To make such a decision, I examined students’ responses to probes through which I required them to elaborate their understanding of scientific language adopted. If the students’ responses failed to forge connections showing conceptual understanding of the ideas investigated, I considered them as still operating in their everyday culture and thus belonging to group X. Table 7 shows the initial codes, sub codes, their definitions and exemplars of the conversations under each one of them.
Table 7: Definitions and examples of initial codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Sub code</th>
<th>Definition</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyday ways</td>
<td>Everyday language</td>
<td>Words or descriptions and explanations that did not contain scientific terminologies, and those that mean different things in English</td>
<td>- the water has boiled so much that is why air is coming out of it</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Given that it has rained the smoke is coming out</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> in both of these cases, ‘air’ and ‘smoke’ refer to water vapor</td>
</tr>
<tr>
<td></td>
<td>Everyday observations</td>
<td>Descriptions that show a reliance on superficial characteristics or features for understanding</td>
<td>- As for the one of the <em>sufuria</em> cover, the water droplets on it were many but [the ones on the grass] they are not.</td>
</tr>
<tr>
<td></td>
<td>Experience</td>
<td>Descriptions that imply the participants as witnesses or and/or executers of events/actions being described</td>
<td>- I have seen batteries that have no fire being placed on iron rooftops when the sun is shining</td>
</tr>
<tr>
<td></td>
<td>Cultural knowledge</td>
<td>Descriptions and talk from sources other than the participants</td>
<td><strong>Note:</strong> ‘fire’ here refers to battery voltage.</td>
</tr>
<tr>
<td></td>
<td>Scientific language</td>
<td>Scientific words, or descriptions expressions, explanations that drew on scientific language</td>
<td>- The salt dissolved</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- The process is evaporation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The scientific terminologies in these statements are dissolved and evaporation</td>
</tr>
</tbody>
</table>
As I coded transcripts of the focus group discussions, I simultaneously translated conversations in Kiswahili or Kimaragoli to English and wrote reflections on ideas I thought were emerging from the data. This initial analysis was followed by a more focused analysis where I sought to determine themes or patterns in students’ conversations with regard to their conversations about the ideas inherent in the phenomena investigated. Edraw Mind Map™ software became a useful tool for this. It allowed me to create what I like to call “round table conversations” based on the initial codes. I did this by isolating the main ideas arising from the students’ conversations based on the initial codes both for the outside- and inside-the-classroom contexts represented by Part I and Part II respectively on the maps. I wrote these ideas on circular or oval shapes representing the tables. For some of the tables, the ideas on them were basically questions I posed to the students. In such instances the ideas on the tables are followed by “...”

On each table, I represented the students’ conversations around it using colored squares or rectangles with each student having his/her own color code. In working with Edraw Mind Map, I noticed that some tables had only one student’s conversation around it. This was not a problem for me. What I considered important was the ability to have a bird’s eye view on ideas students brought out through their discussions. Other notations on the maps were round tables with dotted outlines representing ideas on the main topic arising from the subsequent discussion; squares or rectangles with a green thick continuous outline representing students’ accurate scientific talk; squares or rectangles with a green thick dotted outline representing accurate scientific talk but contradicting earlier information by the same participant; squares or rectangles with a red thick continuous outline representing idea (scientific or otherwise) mixing or confusion; squares or rectangles with a red thick dotted line representing idea confusion but also
contradicting earlier information by the same participant; squares or rectangles with a black thick dotted outline representing experience with the phenomena implied in the participant’s talk; uncolored squares or rectangles with dotted outlines representing my own reflections.

I assigned numbers to the tables starting with 1 up to however many tables there were on a given page to help me keep track of the conversations. Thus, the order of the table numbers roughly approximated how the discussion progressed. Figure 3 shows a representation of students’ round table conversations for part of the discussion of the idea of dissolving outside-the-classroom context on the Edraw Mind Map™. For a representation of the full discussion on the idea of dissolving on Edraw Mind Map™ see Appendix E. The left hand side of the map represents the outside-the-classroom context discussion while the right hand side represents the inside-the-classroom context discussion.

While it was possible to create round table conversations for most of the ideas investigated, it was not possible with the discussion on static electricity. The discussion on static electricity was a unique discussion session because I talked less. The students did most of the talking through volunteering information, challenging and asking each other questions for clarification. Therefore in representing students’ ideas on static electricity on Edraw Mind Map™, I used numbered loops in addition to the table number idea to help me navigate the discussion. The tail of the loop represents where the discussion began and the arrowhead where it ended on a given idea. The order of the loop numbers just like the order of the tables also roughly approximated how the conversations progressed.
Figure 3: Representation of part of the students’ talk about the idea of dissolving for outside-the-classroom context on the Edraw Mind Map™

Figure 4 shows a representation of the students’ talk on the Edraw Mind Map™ utilizing both the table and looping idea for part of the outside-the-classroom discussion of the idea of static electricity (specifically thunder and lightning). For a representation of an expanded discussion of the same idea on Edraw Mind Map for students’ conversations based on a combination of loop number and table number see Appendix F.
To show that the rain was about to start raining there was thunderstorm and lighting. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

I think that the weather started to change before the thunderstorm appeared. And it appeared because of the presence of clouds that is when the weather started showing signs of changing.

It is also said that when there is such rain one is not supposed to be outside because the lightning can “hit” you. So lightning can “hit”, “beat”, “find”, “burn”, or “pass with” people or things.

And if you are in the house you are not supposed to be at the corner of the house or... lean on the wall.

Also if such rain happens to find when you are walking you are not supposed to step in the water. It can “beat” you.

Another one is that you are not supposed to walk with anything sharp. Lightning can pass through and "find" you.

To show that the rain was about to start raining there was thunderstorm and lightning. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

Thunderstorms start with cloud cover.

1. Thunderstorm and lightning lead to rain.
2. Thunderstorms start with cloud cover.
3. Things/Places to avoid
   - Like what?
   - An umbrella
   - Lean on the wall

**Figure 4:** Representation of part of student’s talk about the idea of static electricity for outside-the-classroom context on Edraw Mind Map™

Mapping students’ conversations on the Edraw Mind Map™ enabled me to see more clearly the themes that emerged through the data. In addition, I was able to see not only which student(s) contributed to what ideas but also the level of contribution by individual students. This is something I was not able to see following the data coding process.

**Writing of the findings.** Following the representation of data on the Edraw Mind Map™, I wrote analytic memos (Saldana, 2010) through which I identified emerging themes or patterns that helped me attach meaning and interpretations to the data (Lofland & Lofland, 1993; Silverman, 2000). I found that for the most part, students adopted everyday ways of talking about the ideas involved in the phenomena investigated in this research both outside- and inside-
the-classroom contexts. These ways included: (1) the use of everyday language (i.e., words and phrases) and a reliance on everyday observations in describing and explaining of ideas investigated. Furthermore, experience with the phenomena investigated in this research seemed to influence not only the students’ understanding but also the choice of words used to describe the phenomena, (2) cultural talk about the nature and form of lightning different from that emphasized in science emerged through this research and (3) the findings of this research show possibilities for students who may initially seem uninterested in participating in discussions involving science ideas to participate. I have presented these ideas in Chapters Four and Five of this dissertation.

I want to make a clarification of some decisions I made with regard to the writing the remaining chapters of this dissertation (i.e., Chapters Four, Five and Six). First, there was no overwhelming general common talk and consensus among students for any of ideas investigated in this research. Indeed, there were ideas where only one student made a contribution. Thus, in using the word students throughout this dissertation, it should not be construed to mean all the students who participated in this research. Rather, it means at least two students held the idea(s) being described. Second, Kenya uses spelling and conventions based on the British system. Thus even though this research was conducted in Kenya, I have adopted the spelling and conventions of the American system except for units which I provide for both systems. Third, the language used during the focus group discussions for the outside-the-classroom context was Kiswahili and to a small extent Kimaragoli, the student’s community language. Thus, while the quotes from the students’ conversations for the outside-the-classroom context may be in English, they are actually English translations of the students’ conversations in either Kiswahili or Kimaragoli. Also, to a small extent students used Kiswahili in talking about ideas in the inside-the-classroom
context. Whenever I use quotes from such conversations, I have indicated that the original conversation was in Kiswahili. Finally, as a marker, any word or phrase that is not a quote by the student(s) bearing the single quotation marks illustrates that the word or phrase is an everyday word or language.

**Biases, Barriers and Opportunities**

(Peshkin, 1988) argued that it is important for a researcher to go beyond acknowledging his or her own positionality in a given research and be explicit about how the positionality impacts the conduct of the research. For this reason, I discuss some of the biases, barriers and opportunities in this research in this section. One of the things that could easily have affected the findings of this study was my insider role of being able to speak the same language as the students. The language gave me the ability to understand words or phrases for the things the students talked about during the focus group discussions. Therefore, it was going to be possible for me to consciously or unconsciously affirm or disconfirm them and as a result influence not only what the students said but also how they said it. Also, the ability to speak the same language as the students could easily have driven me into the temptation of wanting to impose my own interpretations to the words or phrases students used during the discussions. However, going into this research knowing that my ability to speak the same language as the students could influence almost all aspects of this research, and in particular the data collection and analysis processes, helped me accept the students’ words as they used them. Additionally, as mentioned earlier in this chapter, I was conscious of and sought the students’ clarifications on words or ideas from preceding discussions which I was not clear about during the discussions that followed. I also enlisted the support of a Kiswahili teacher from a different school to help confirm that both my
translations of students’ talk from Kiswahili to English and my interpretations of their talk were accurate.

However, several times during the focus group discussions I forgot my role as a researcher and instead my mind drifted away into my earlier days of growing up, especially when the students talked of things I was familiar with from those days. In such instances, and in particular when it involved animated talk and laughter among the students, I found myself also joining in their laughter sometimes to the extent of not being in a position to continue focusing and directing the discussion. I had to constantly remind myself that my goal for sitting with the students was to collect data. This then helped me in regaining the ability to refocus and move the discussions forward. Additionally, while I tried to probe the students further on their ideas, it was challenging for me to determine how far to go in terms of making sure that the students remained comfortable to continue engaging in the discussions and not feel like I was putting them on the spot. In most such cases, I found myself accepting the students’ ideas as presented just in case I made them uncomfortable by probing further.

Notwithstanding these biases and barriers, my positionality as an insider helped push the agenda of this research forward. Coming from the community in which I conducted this research enabled me to gain a smooth entry to the research site. I knew the location of all the schools in the constituency and could reach any of them without seeking help from anyone. This is something I do not want to take for granted. Also, as an insider, I was looked at as ‘one of our own’ meaning someone who cannot harm his or her own people. Most of the people I met during the data collection period were happy to see me go in and out of the school even though they did not understand what I was doing in the school. I remember one remarking that it was good of me to think of teaching “our children.” To an extent, this encouraged and boosted my morale.
Additionally, this research provided me with an opportunity to put to practice the research skills I had learned through the graduate program, and specifically organizing and managing focus group discussion sessions, data analysis and reporting of the findings. This research has shown that there is an extra layer of complexity SLSL2 have to grapple with regard to learning science – talking about scientific phenomena outside-the-classroom contexts in ways that are different from those emphasized in the science classroom. Based on this, I propose just like other scholars (e.g., Ballenger, 1997; Fradd & Lee, 1999: Fradd et al., 2001; Lee, 2004; Warren et al., 2001) that these ways are rich starting points for leveraging students’ science learning in meaningful ways – ways that enhance understanding as opposed to rote memorization of concepts.

**Chapter Summary**

In this chapter, I described the methods I adopted in this research and provided a rationale for their adoption. I have also stated how my positionality as an insider may have impacted this research in addition to areas of barriers and opportunities in this research. In the next chapter, I describe the findings related the students’ adoption of everyday language, everyday observations and experience in talking about ideas inherent in the phenomena investigated.
Chapter Four – Findings: Everyday Language, Everyday Observations and Experience in Talking about Scientific Phenomena

Introduction

In this chapter, I begin answering three of my research questions concerning how students talked about given physical science phenomena both outside- and inside-the-classroom contexts and how their talking in both contexts were not only similar or different to each other but also to those emphasized in science classrooms. The final part of the answer to these questions is described in Chapter Five. To enable me to answer these questions I explored one main data set – transcripts of students’ focus group discussions obtained as they engaged in talking about selected physical science phenomena outside- and inside-the-classroom contexts. I supplemented these data, with data from transcripts of interviews with two teachers, (i.e., one chemistry teacher and one physics teacher), the syllabus on objectives, content and level of treatment of content involving ideas investigated in this research and students’ responses to questions involving ideas investigated in this research on teacher-made assessments.

As mentioned in Chapter Three, I cued the students to experience phenomena outside-the-classroom context through videos and pictures on my laptop computer prior to commencing the discussions, while for the inside-the-classroom context I conducted hands-on-activities or demonstrations using apparatus and materials as would have been done inside the science classroom to cue them before commencing the discussions. I found that the students adopted everyday language (i.e., words and phrases) in describing and explaining of ideas investigated outside-the-classroom context. These words and phrases also filtered into the students’ talk as they described and explained some of the ideas in the inside-the-classroom context. Also, the students relied on everyday observations for their explanations of ideas inherent in the
phenomena and activities investigated. Experience with the phenomena investigated in this research seemed to influence the students’ choice of words used to describe and explain ideas in the phenomena investigated.

In the following sections, I describe the patterns in students’ talk starting with everyday language in talking about scientific phenomena. This will be followed by everyday observations and experience in talking about scientific phenomena. I will also relate the students’ talk to the science curriculum, the teaching and ideas assessed by drawing on data from the teachers’ interviews, the syllabus, and students’ responses to questions on teacher-made assessments on ideas investigated. The purpose for doing this is to make connections between the findings and the frameworks that guided this research. At the end of the chapter, I provide a summary of the findings as described in this chapter.

**Everyday Language in Talking about Scientific Phenomena**

The idea of everyday language in science education is not new. Scholars such as Ballenger (1997) and Warren et al. (2001) have shown that everyday language is a tool for meaningful engagement and participation in science, especially for students whose everyday culture may be different from that of the science classroom. Both of these scholars conceive everyday language as the first language of the students. Through their studies, it was shown that the students who participated used their first language (specifically, Haitian Creole) and engaged successfully in talking about ideas in science. According to these scholars, the students’ first language enabled them to bring their personal experiences (i.e., bathroom cleaning) and ways of acting (i.e., storytelling and drama) to the science task at hand. As a consequence, there was a shift in the students’ thinking and talking using everyday language to thinking and talking using
scientific language (Warren et al., 2001) and asking questions that could be investigated scientifically (Ballenger, 1997).

In this research, just like Ballenger’s (1997) and Warren et al.’s (2001), the students drew on a language other than the language of instruction (specifically, Kiswahili) to talk about ideas inherent in the phenomena investigated outside-the-classroom context. However, words and phrases adopted by the students to describe and explain the ideas in this context filtered their way into the inside-the-classroom context when talking about some of the ideas investigated. In this section I describe these patterns. Prior to this description, I provide an overview of the ideas investigated that includes terminologies and explanations involved.

**Overview of ideas investigated.** This research investigated ideas students learn about in school science as well as experience in their lives outside the classroom in terms of how the students talked about them. The ideas are dissolving, evaporation and condensation addressed in chemistry and static electricity and electric current addressed in physics. The students experience phenomena and activities involving these ideas in their lives. For example, dissolving is involved in everyday activities such as the addition of salt and sugar to food, while evaporation and condensation ideas are involved in phenomena and activities such as the steam forming on roads or rocks following rain on a hot day, cooking and dew on grass during morning time. Static electricity is involved in phenomena such as thunderstorms on a large scale, and static cling and/or sparks and cracking sounds when undressing (especially in the dark) with certain kinds of clothing, shocks from door handles and knobs – on a small scale while electric current is involved in activities such as phone battery charging and battery use in radios and flashlights.

**Dissolving.** This is a term most commonly used to describe the process by which a solute (solid substance) breaks down into tiny particles that get incorporated into a solvent (liquid
substance) in which it is added and stirred to form a solution (uniform liquid mixture). It is because of this break up of a solute into tiny particles and the incorporation of the particles in the solvent that makes a solute appear like it has disappeared following dissolving.

**Evaporation.** This is a term used to describe the process by which a liquid substance changes to its gaseous form or state (often referred to as vapor) on heating when the atmospheric pressure is constant. Generally, the particles in a liquid are not only close to each other but also in constant motion moving in all directions in the liquid structure. When a liquid is heated, the heat supplies the necessary energy to cause the particles in the liquid state to move not only far from one another but also more frequently and vigorously until they break loose from the liquid structure and become a gas. If the substance being heated is water, for example, the vapor formed is known as water vapor or steam. This is easily visible and therefore may be seen rising above the water as the heating continues. It is important to note that evaporation can occur even when the presence of heat does not seem obvious (i.e., in the case of a team forming on a road or rock). In the case of a steam forming on a road, for example, heat from the sun heats up the paved road on a hot day and if it happens to rain on such a day, the heat accumulated on the road heats up the water on the road making it change to its gaseous or vapor form, which may be seen rising in a similar manner as vapor from cooking food or boiling water.

**Condensation.** This is a term used to describe a process by which a substance changes from gaseous (vapor) state to liquid state when cooled given a constant atmospheric pressure. Condensation can thus be thought of as being the reverse of evaporation. This is because when particles in vapor come into contact with a cooler surface the lower temperature of the surface makes them to move not only less frequently but also less vigorously. This causes the particles move close to one another, hence forming a liquid. While it does not have to be the case always
the liquid that is formed arising from condensation appears as droplets such as those observed on the covers of cooking pans during cooking or dew on grass in the morning.

**Static electricity.** Static electricity is an idea involving not only the formation of charges (physical property of matter that causes it to experience a force when close to other charged matter) but also attraction between opposite charges and repulsion between similar charges. Rubbing of surfaces or bodies including people and material things (e.g., clouds, clothing) is the main process by which the charges form. In science, it is believed that bodies are neutral (the number of negative and positive charges in the body are equal) but when rubbing occurs between two bodies, one body may transfer some of its negative charges (because of their ability to move) to the other body and remain with more positive charges than the negative charges while the body that receives the negative charges will have more negative charges than positive charges. This may happen without the bodies changing their form or nature. In other words, the process of charging of bodies in everyday interactions is not observable. If a body that has more of one type of charge (positive or negative) than the other comes in close proximity with another body having more of the opposite charges, attraction occurs based on the principle of opposites attract. This attraction is the cause of phenomena such as thunderstorms and static cling.

**Electric current.** By definition, electric current is the flow of electric charge across a conductor per unit time as a result of a potential difference. A conductor is a material mostly made of metal that allows electricity or heat to pass through it but remains unchanged as a result. For purposes of electric current conduction, conductors are metals (preferably made of copper) drawn into wires. Naturally, metals have electrons (negatively charged particles) in their structures that are easy to move. These electrons facilitate the movement of a charge in the conductor. A potential difference that is sometimes referred to as voltage and measured in volts,
can be thought of as the cause of the flow of current (charge per unit time) across a conductor. A battery is a good example of a material with a potential difference. It is designed such that there is a buildup of more charge at one end than the other end. The buildup of more charge at one end of the battery creates a potential difference between the two ends of the battery.

Given a wire with ends A and B, if A is connected to one end of a battery and B to the other end, electric current flows through the wire because of the potential difference between the battery ends. The wire AB is the conductor while the battery provides the source of the charge as well as potential difference that causes the electric current to flow across the wire. Simply put, and without going into details of the structure of a battery, if any part of the above hypothetical wire AB connected to the battery as described is cut and a bulb connected at this point, the bulb should light because some of the electric current flowing through the filament (a thin piece of metal inside a bulb) is converted to heat energy. Thus, the filament heats up to the point where it glows and produces light. For some batteries, such as those used in phones and cars, most of the charge simply accumulates at the opposite end of the battery and therefore, by plugging them in an electricity supply, the charge is pushed back to its original end. Such batteries are referred to as secondary cells. There is, however, another type of battery – the primary cells that are not rechargeable. This means that once the ends of the battery have equal amounts of charge, it marks the end of the use of the battery.

Of the ideas presented above, it is only dissolving, evaporation and condensation where the students adopted words and phrases outside-the-classroom context that were replicated in the inside-the-classroom context. In the following sections, I describe the students’ talk about these ideas starting with the students’ talk about dissolving both outside- and inside-the-classroom
contexts. This will be followed by the students’ talk about evaporation and condensation both outside- and inside-the-classroom contexts.

**Students’ talk about dissolving.** I used video #2 of Petronila (arbitrary name assigned to the person in the video) cooking vegetables, specifically *sukuma wiki* (kale), to cue the students to experience an everyday activity involving the concept of dissolving before commencing a discussion outside-the-classroom context. I asked the students to talk about why Petronila stirred the vegetables after adding salt and what would happen if she did not stir the vegetables. I found that students understood the reason for stirring the vegetables was to ensure all parts of the vegetables had salt including those at the “bottom,” as noted by Yohana. For example, Kayali stated “[Petronila] stirred for the salt to mix well in the vegetables. If she doesn’t stir, the salt will not be in some parts of the vegetables.” Aliviza also had the same idea of salt ‘mixing well’ with the vegetables but added that it was not just the salt that needed to mix well with the vegetables. According to her, stirring was done to ensure that other ingredients, such as onions and tomatoes, ‘mix well’ with the vegetables too. She stated, “[Petronila] put the salt then picked the spoon and started mixing so that the vegetables could mix well with the salt together with the tomatoes and onions.” For these students, stirring the vegetables after the salt had been added meant that the salt needed to ‘mix well.’

Interestingly, the idea of ‘mixing’ was extended in the discussion on dissolving in the inside-the-classroom context except that the word ‘well’ was replaced with ‘up.’ To cue the students for the inside-the-classroom context discussion I added water to a test tube containing salt. I shook the test tube and its contents and asked the students to talk about what had happened to the salt. Yohana observed correctly that the salt had dissolved. A follow up on what Yohana meant by the phrase “the salt had dissolved” brought out the idea that “the salt had dissolved”
means that it had ‘mixed up.’ It is Kayali who initiated the idea of salt getting ‘mixed up’ with water to mean dissolved. She stated, “The salt has been mixed up by the water.” Muhonja, Matini and Kayali had this same idea and indeed said it in unison as an answer to my question of why the salt could not be seen after the test tube shaking action. They stated “it has mixed up with the water.” Thus, dissolved for these students meant that the salt had been ‘mixed up’ with the water, which also was the reason behind the salt not being able to be seen following the shaking action.

Even though the word dissolved (a scientific terminology) had been used in the inside-the-classroom context to state what happened to the salt in a test tube after adding water and shaking the test tube and its contents, the idea of ‘mixing’ used outside-the-classroom context stuck with the students as the reason behind why the salt could not be seen following the shaking action. While there may be nothing wrong with the phrase ‘mix up’ as the reason behind the salt not being visible following the shaking episode, its use covers only part of the reason – the incorporation of the smaller salt particles into the water to form a salt solution. Indeed, the incorporation of the small particles in the solution takes place after the break-up of the solute, which is not captured by the phrase ‘mixed up.’

**Students’ talk about evaporation and condensation.** Just like the case of dissolving where the students adopted words outside-the-classroom context that filtered into conversations in the inside-the-classroom context, the students also adopted the word ‘smoke’ in discussing about evaporation outside-the-classroom context that also filtered into their discussions in the inside-the-classroom context when talking about both evaporation and condensation. I used video #3 of the steam forming on the road and video #4 of water in a *sufuria* over fire to act as cues for the phenomenon of evaporation in an outside-the-classroom context. In talking about the
happenings in videos #3 and #4, the word *moshi* (Kiswahili for smoke) was used to describe water vapor formed during evaporation. The use of the word ‘smoke’ was initiated by Matini who used it to describe water vapor formed on the road in video #3. He stated, “it is like the sun was very hot. Then as soon as the sun got finished, it rained. Given that it has rained smoke is coming out.” Steam or vapor is referred to as *mvuke* in Kiswahili and *omwika* in Kimaragoli, but rather than use the word *mvuke* given that he was speaking Kiswahili, Matini chose to use the term ‘smoke.’

Generally, whether people are speaking Kimaragoli or Kiswahili, they refer to steam (on the road and rocks following a hot day and cooking food) simply as ‘smoke.’ This way of talking about steam or vapor in everyday life might have influenced Matini in describing the steam on the road. The word ‘smoke’ for water vapor was also adopted in talking about water in a *sufuria* over fire as seen in video #4. For example, Kayali stated, “as the fire was burning, the water was boiling so much such that bubbles were visible. But as the fire went down, the boiling started to reduce and therefore not so much smoke was coming out.” Just like Matini, Kayali also chose the word ‘smoke’ for steam, despite having the option of calling it *mvuke*.

The adoption of the word ‘smoke’ in talking about evaporation outside-the-classroom context was also extended in the discussions about evaporation and condensation in the inside-the-classroom context, although most of the time the students referred to the substance produced when water was boiling in the beaker as air and the substance formed on the watch glass (see below for the description of demonstrations) as water. I initiated the discussion for the inside-the-classroom context on these ideas by carrying out two demonstrations to illustrate evaporation and condensation. Specifically, I heated some water in a beaker over a Bunsen burner flame until it started to boil to illustrate evaporation. While the water was continuing to boil I covered the
beaker with a watch glass on which water droplets formed to illustrate condensation. Condensation was further illustrated by heating one spatula (an apparatus made of metal or wood used for scooping chemicals in the laboratory) end full of hydrated copper (II) sulfate in a test tube until droplets of a liquid formed on the cooler parts of the test tube near its mouth. Just like in the case of the discussion outside-the-classroom context, I asked the students to talk about what they had observed in the demonstrations and why they thought things happened that way.

In describing what was happening to the water in the beaker as the heating continued, Aliviza adopted the word ‘smoke’ to refer to the water vapor. She stated:

Now when the water starts to boil, there are bubbles at the bottom of the beaker. Then smoke starts to come out as the water continues becoming hot. As the water continues to boil and becoming hot, the bubbles move from the bottom to the top.

This whole conversation by Aliviza was done in Kiswahili on her own volition even after I asked the students to use English to talk about ideas in the inside-the-classroom context. Interestingly, Muhonja whose entire conversation was in English also used the word ‘smoke’ as she described the formation of the colorless droplets of liquid on the cooler parts of the test tube following the heating of hydrated copper (II) sulfate in the test tube. She stated, “when we were burning hydrated copper (II) sulfate there was some smoke which was coming inside it and then that smoke did not go out all of it. Some of it formed that water.” I also noted that rather than use the term heating to describe the action of holding copper (II) sulfate in a test tube over a Bunsen burner flame, Muhonja adopted the term burning. Burning has implications of something being set on fire.

The findings of this research are consistent with those of Khatete (1995) with regard to the students’ use of the term ‘smoke’ to refer to water vapor. As noted earlier, Khatete explained
that the students in his study had no terminology in their community language for water vapor. Rather, water vapor was referred to as ‘smoke’ Unlike in Khatete’s study, the students who participated in this research had choices of words both in Kiswahili and Kimaragoli (i.e., mvuke and omwika, respectively) they could have used to describe the substance formed during evaporation of water. The use of the word moshi for water vapor rather than mvuke by the students who participated in this research may mean that there is more to the choice of terminology for describing scientific phenomena than just lacking the appropriate terminology.

The adoption of everyday language (words and phrases) was also evident in the students’ talk about the other ideas investigated (i.e., static electricity and electric current) outside-the-classroom context. However, unlike the case of dissolving, evaporation and condensation, the words and phrases adopted did not filter into the discussions about these ideas in the inside-the-classroom content. For example, the students adopted the word ‘sticks’ for attraction between charged particles when talking about static electricity and specifically static cling. Additionally, they adopted the word ‘fire’ to describe not only electricity but also voltage when they talked about charging the phone battery in video #7 and flashlight’s batteries. In the following section I describe patterns in students’ conversations to show how they relied on “everyday observations” (Eberbach & Crowley, 2009) and the role of experience in that, as well as how experience might have influenced their choice of words used to describe and explain the ideas investigated in this research.

**Everyday Observations and Experience in Talking about Scientific Phenomena**

Researchers acknowledge that observation is one of the process skills requisite in science learning (Eberbach & Crowley, 2009; Ford, 2005; Jegede & Okekubola, 1991; Padilla, 1990). Central to observation is the use of senses “in gathering data about an event or object” (Padilla,
While recognizing the importance of sense organs in observation, scholars have attempted to differentiate between types of observation. For example, Eberbach and Crowley (2009) distinguish between two types of observation – everyday and scientific. In contrasting the two, they note that everyday observations are “those that occur with little or no knowledge of the constraints and practices of scientific disciplines” (p. 46) and add that “everyday observers fail to notice the right things. Instead, they notice many irrelevant features and behaviors that fail to forge connections or support deeper understanding of complex phenomena” (p. 49). This means that for observation to be scientifically meaningful, the observer needs to have the ability to make connections that lead to the understanding of the phenomena being studied, without which, the observer ends up making observations that are largely descriptive, or what Ford (2005) refers to as “creative descriptions” (p. 286).

In this research, the group discussions were taken to a level where I asked the students to compare phenomena and related ideas as presented to them not just with outside- or inside-the-classroom context but also between those outside- and inside-the-classroom contexts. Part of the reason for doing this was to determine whether students viewed the phenomena as being similar or different in a given context(s) (i.e., outside- and inside-the-classroom). Thus, I posed questions requiring the students to talk about similarities and differences between the phenomena investigated in a given session or previous sessions and give reasons for why they thought the phenomena were similar or different. It emerged that while students were able to state that similarities and differences existed between the phenomena in question, for the most part explanations given for the similarities and differences were mainly descriptive or everyday observations. In other words, from the students’ explanations it would be difficult to make connections leading to effective or deep understanding of the scientific phenomena investigated.
As a consequence, some of the students stated that there were differences between given phenomena even where there were no differences conceptually. In addition, the reliance on everyday observations as a tool for explaining their ideas seemed to stem from the students’ experiences with the phenomena investigated in this research. Furthermore, experience with the phenomena investigated in this research seemed to influence the students’ choice of words used to describe and explain the ideas. In the following sections, I describe students’ talk about the phenomena investigated in this research based on everyday observations and how experience may have played a role.

**Everyday observations in talking about scientific phenomena.** One of the discussions where it was clear that students relied on everyday observations in their understanding of phenomena investigated was the discussion on condensation. To the question of whether or not there were similarities and differences between the droplets on the *sufuria* cover in video #5 of a *sufuria* containing water over fire, covered and uncovered and those on the grass in picture #3, Matini asserted, “there is a difference and in fact a big one.” And noted that, “as for the one on the *sufuria* cover, the water droplets on it were many but [on grass] they are not.” Here, Matini focused on the amount of water droplets and yet there was more to this phenomenon than just amount of water droplets. Indeed, the two phenomena are similar in the sense that the water droplets on the *sufuria* cover and those on the grass formed through the same process – condensation. In other words, Matini focused on an irrelevant detail (i.e., amount of water) and failed to notice the role of the *sufuria* cover being cooler than the steam which helped in cooling the steam to become the water droplets just as the cold in the night causes the formation of dew on grass as in picture #3.
Similarly, even though Kayali, Aliviza and Imali collaborated by completing each other’s sentences and in communicating their thinking that there was a difference between the water droplets on the sufuria cover and grass in picture #3, they failed to notice the similarity as explained above and instead focused on an irrelevant difference (heat for water in the sufuria over fire versus no heat in picture #3) as shown by the following conversation:

Kayali: As for the one used by Petronila to cover the sufuria, the water was cold but not very cold. But for this one [on grass], the water is very cold.

Researcher: Which one is cold Kayali?

Kayali: This one of…..(laughs)

Aliviza: When Petronila covered the sufuria, the water on the cover resulted from…..

Imali: ..... the water in the sufuria

Aliviza: Since the water was hot, it is the one that made the cover to have water but this one doesn’t come about as a result of heat.

Just like Matini, Kayali, Imali and Aliviza also missed out on the role of the sufuria cover in having a lower temperature than the steam helped cool the steam to become water droplets.

These students’ conversations brought out aspects of the phenomena that were visible to the eye but unconnected to the main idea of condensation and how it occurs. In other words, the students’ explanations were those that relied on everyday observations. The use of sense organs, and especially the eyes, in learning science cannot be overemphasized. However, students need to be in a position to make connections based on their observations that lead to sound understanding of the science behind what they have observed. For example, while water droplets may be observed on the sufuria cover, the actual change of the steam molecules or particles to liquid water molecules is unobservable. An understanding of the conditions necessary for such a
change needs to be clear before connections are made that lead to why the water droplets are observed.

It is not just in talking about similarities and differences between phenomena in both the outside- and inside-the-classroom contexts where students demonstrated a reliance on everyday observations in explaining ideas about the phenomena investigated in this research. It also happened even when they discussed what they had observed in the videos and pictures, as well as demonstrations in both the outside- and inside-the-classroom contexts. For example, in the demonstration on dissolving where salt dissolved in water in a test tube and therefore could not be seen, I asked the students to explain how I would go about determining whether or not there was salt in the resulting solution. Muhonja stated, “when you added it, you shook it and mixed it with the water. Now if you taste that water it will have salt.” According to Muhonja, tasting the solution was a sure way of knowing that the solution contained salt. While tasting may work in this particular case, it could turn out to be tragic especially if the substances involved were poisonous. Indeed, when I raised the idea of poisonous substances Aliviza still stuck at the level of relying on everyday observations in her explanation of what I would do to know that the solution had salt. She stated, “you will know it is there because you added it there.” As noted, students need to be a position of making connections based on their observations that help them move to higher levels of learning science and even recognize other ways of knowing such as experimentation. In the preceding example, for instance, the students could have talked of heating a small amount of the solution until all the water evaporates to leave behind salt or checking the boiling point of the solution in which case it would have been higher than the boiling point of pure water because salt would be acting as an impurity in the solution.
The findings of this research with regard to students providing descriptive observations and tending to rely on everyday observations to explain ideas investigated are consistent with findings of a study conducted with third graders learning ideas in geology (Ford, 2005). Working with third graders and their teachers, Ford observed the students learning geology ideas, specifically identification of rocks and minerals. She also examined the students’ notebook entries. From the notebook entries, she found that the students’ writing was what she describes as “creative descriptions” (p. 286) of rocks. She noted that the students’ writing tended towards creative writing rather than scientific writing (i.e., “shaped like a mountain” and “shape as a fish head” (p. 286). From these kinds of observations, it would be difficult for students to understand the science behind rocks and minerals and how they form.

**Experience with the phenomena.** The students’ reliance on everyday observations as a way of knowing and explaining their ideas seemed to stem from their experiences with the phenomena investigated in this research. In the case of salt and water, Aliviza had earlier on in the discussion stated that if Petronila realized that she had added salt to the vegetables beyond the required amount, she would have to taste a little of the vegetables before deciding on whether or not to add more. She stated, “now if she has put less salt, she will eat a little of the vegetables to be sure that the salt is enough or not enough then she adds more.” In cooking, generally among Africans cooking in a traditional way, it is unusual for recipes to be used. The skill of cooking is perfected through practice and when salt or other spices are added to food, it is often done through approximation. A little of it is added at first and then the food is tasted to determine whether enough was added. If not, then more is added. This practice seems to have influenced Muhonja in her response on how I would know whether or not the water in the test tube had salt. After all, she may have reasoned, “Isn’t it salt we are talking about here?”
Similarly, the experience of baking over hot sand could have influenced Matayo’s thinking that the colorless droplets formed on the cooler parts of the test tube when copper (II) sulfate was heated came from heat arising from the flame of the Bunsen burner. In a discussion about the demonstration of heating hydrated copper (II) sulfate in which colorless droplets of a liquid formed on the cooler parts of the test tube, Matayo referred to the droplets as water and stated that they came from heat. When I made a follow up during the discussion that followed on whether he had seen something where heat made droplets to form that way, he stated that he had and talked about heated sand in a sufuria as shown by the following conversation.

Matayo: I have seen,
Researcher: Where? If you can talk about that, it would be good.
Matayo: Like when you put sand on a sufuria and heat it.
Researcher: When you do what?
Matayo: Put sand on a sufuria.
Researcher: Ok.
Matayo: Then you cover the sufuria. Some water will be on the top covering.

This entire conversation was done in English. That is why I left the phrase “sand on a sufuria” intact. What the Matayo might have meant was, “sand in a sufuria.” This is because the use of heated sand in a container such as a sufuria is a common method of baking among people who do not own stoves with ovens, especially in the rural areas. Basically, sand is placed in a sufuria and preheated before a smaller sufuria containing the cake mixture to be baked is placed in a depression created in the hot sand and the sufuria containing sand covered. The heating continues until the cake is ready. I am inferring this is what Matayo may have been talking about. What Matayo and other students such as he may fail to understand is that in between the
sand particles is moisture and therefore when heated, the moisture can change into vapor and if the vapor comes into contact with a cooler surface, it can condense to form the water droplets.

Likewise, the experience with batteries seemed to have influenced Kayali in her explanation for knowing whether or not a battery had enough voltage: “If you want to know that the battery is low⁹, it forms depressions when you press it, the depressions are easy to form on it. But when it is still new and you press it, it will not form depressions.” Ideally, what Kayali was communicating here is that she really does not need a voltmeter to know whether or not a battery is low. Her hands were good enough for the job. Pressing batteries to determine whether or not they had enough voltage is something I am familiar with because while growing up I used to see my brothers doing it. However, by the time a battery starts to make depressions when pressed, its voltage may be way too low. Therefore, pressing may not be a reliable way of knowing the voltage status of a battery. More importantly, there may be implications of this experience for science teaching and learning where other ways of determining the voltage status of batteries (e.g., using a voltmeter) are used.

Other than seeming to influence the students’ ability to know and understand ideas investigated in this research, experience also seemed to influence the choice of words used to describe phenomena investigated in this research. For example, the students referred to the substance on the grass in picture #3 as water. When I asked them to explain why, Matini stated, “It is like when you pass where there is a lot of grass and it has water on it. When you arrive at your destination, you find that your clothes are wet.” The village life in the location where I conducted this research is such that people are free to move from place to place (e.g., visiting friends, fetching water, looking for wood). Sometimes they use footpaths that are overgrown with grass. If one passes through such a path early in the morning his/her clothes become wet.

⁹ The participant said imeisha (Kiswahili for “it is finished”).
This could have been what Matini was talking about. This experience of clothing becoming wet coupled with the experience of washing clothes and the wetness that accompanies it may have led the students into referring to the dew on grass as water.

Similarly, the experience with batteries when they are determined to be low in voltage could have been responsible for Imali’s choice of the word ‘fire’ used to refer to voltage in a battery. The students talked of ways of increasing the voltage in a battery that is determined to be low in voltage. The process involved placing the batteries on iron rooftops or near the fire as shown by the following conversation that arose after I asked the students whether something can be done to increase the voltage of a battery if it is determined to be low:

Imali: They also place [the batteries] near fire.

(Laughter)

Kayali: Yes, for me I have seen batteries that have no fire being placed on iron rooftops when the sun is shining.

Researcher: Fire in the kitchen, when it is burning? Fire from burning wood? Do you remove the batteries from the torch (flashlight) or the radio and place them near fire or on the rooftop when the sun is shining?

Imali: You can place them on the iron rooftop or near the fire.

Researcher: So what happens when you do that?

Kayali: At least it will produce light.

Researcher: Will it produce light even when it was not producing light?

Kayali: Maybe it was producing a small amount of light but then when you put it on the rooftop or near fire as Imali has said . . .

Researcher: Mmmh
Imali: There is some kind of heat that enters it and then (inaudible).

Researcher: What enters it?

Imali: Fire*.

(Laughter)

Researcher: Fire from the burning wood?

Imali: Yes.

The rooftops of most of the houses in the community where I conducted this research are made of corrugated iron sheets. This kind of rooftop is the one Kayali and Imali were talking about where someone can put batteries to dry. The ridges or grooves on the iron sheets provide perfect spots for laying the batteries. Putting batteries on rooftops or near fire is something I am familiar with from the time I was growing up because I watched my brothers doing it. It actually used to work because the battery produced more light than before, but that was only for a short time. I did not understand how and why it worked until I learned the chemistry of a dry cell. Basically, for the batteries that are not rechargeable, the softness may come about because of the thinning out of zinc (the metal casing that acts as the source of charge for the battery) with time because it reacts with ammonium chloride (one of the chemicals inside the battery). There is also an accumulation of water inside the battery arising from one of the chemical reactions inside the battery. Thus, when the battery is put in the sun’s heat or near fire, the water evaporates and that is why the battery produces more light than before, but only for a short time (a few minutes) because more water is produced when use resumes.

Prior to the conversation of batteries and how to increase their voltage when it is low, the students had adopted the word ‘fire’ to describe electricity and voltage in an outside-the-classroom context as earlier mentioned. I used videos #7 of the phone battery charging and a
two-battery flashlight to cue them to experience the phenomenon of electric current before commencing a discussion outside-the-classroom context. I asked them to talk about the happenings in the video and also to explain how a flashlight works to produce light. The word ‘fire’ was used to describe both the electricity as was the case of charging the phone battery in video #7 and voltage in a battery. For example, in reference to what Petronila was doing in video #7, Kayali stated, “The phone had run out of fire, so Petronila took the charger, plugged it in the socket, fixed it on the phone and the phone started charging.” In reference to the flashlight battery, Muhonja stated, “When you buy [batteries] they usually are still having fire. Then after their use, for example, for about two weeks, the fire that was inside reduces because of the light produced while in use.”

The adoption of the word ‘fire’ may have arisen from the fact there is no terminology in Kimaragoli for electricity. In Kimaragoli, electricity is referred to as um’mulo, which translates to fire. However, what was surprising was that there is a Kiswahili terminology for electricity (i.e., umeme), and since the students were communicating in Kiswahili it would be expected that they use the word umeme in describing electricity and or voltage but instead they chose to call it moto (Kiswahili for fire). This could be because electricity shares a number of properties with fire (e.g., it can be used to cook food and produce light). Thus, the adoption of the term ‘fire’ may be more than a linguistic problem and includes the similarity between electricity and fire in terms of what both can do. However, the difference between fire (which arises from burning organic materials) and electricity which basically involves movement of charge, across a conductor as a result of potential difference needs to be clear to students as much as they use the same terminology to refer to both fire and electricity.
More importantly, was Imali’s idea of fire* in a battery when she talked about how a battery’s voltage can be increased if it is determined to be low. Her initial idea was that some kind of heat enters the battery when put on a rooftop or near fire. When I sought further clarification on what she said, she retracted and said fire. I did not know whether she meant fire as in the burning wood or ‘fire’ as electricity (given the earlier conversations about a battery’s voltage as being fire). When I asked her to confirm, she said that it was fire from the burning wood. I starred the word fire as used by Imali because it made me think that, to Imali, what is being referred to as fire in a battery is actually fire. I do not wish to generalize and say that all the students who participated in this research had the idea of voltage in a battery as fire as in one from burning wood like Imali, but the question of how many other students out there who may be having the same idea and how it can influence their learning of the science of electricity is a question of concern and one that certainly requires further inquiry. Equally important is the question of not only how students’ everyday talk about scientific ideas compares with their writing about the same ideas but also interpretation(s) we (teachers, researchers) attach to students’ work (i.e., both verbal and written). (Dotger, Orado, Bearkland, & Dawes, 2014).

Dotger et al observed:

We listen and watch for indications of how they leverage their everyday descriptions of phenomenon in order to understand them, while also working to help them connect these everyday descriptions to the scientific discourse for the same phenomenon. We wonder about how their talk compares with their written work, as well as differences between our interpretations of their ideas in these two formats. (p. 17)

Thus while acknowledging the importance of everyday talk in leveraging student’s learning in science, Dotger et al. also wondered how students’ everyday talk is similar or
different from their written work in addition to differences in interpretations of students’ work in
the two modes (i.e., written and spoken). In addition, I wonder, what the implications are for
differences in the interpretations.

Furthermore, just as the idea of pressing a battery to determine its voltage status could
have implications for science teaching and learning so is the idea of increasing the voltage of a
battery determined to be low in voltage. For example, what would go on in the minds of students
when they are taught that ordinary batteries (primary cells) are not rechargeable when they have
had experiences through which they believe a primary cell’s charge or voltage can be increased
if determined to be low?

**Students’ Talk in Relation to the Science Curriculum, Teaching and Assessment of Ideas Investigated**

The findings of this research as described in this chapter show that the students adopted
everyday language to describe and explain ideas investigated. They also relied on everyday
observations for their explanations of ideas inherent in the phenomena investigated. Furthermore,
experience with phenomena and activities investigated seemed to influence their talk especially,
in the choice of words used to describe and explain the ideas investigated. In the following
sections, I relate these findings to the science curriculum, teaching and assessment of ideas
investigated by drawing on the data from transcripts of interviews with the teachers, the syllabus
and students’ responses to questions on teacher-made assessments of ideas investigated. The
purpose of doing this is to connect the findings to the theoretical frameworks that guided this
research with a view of providing some insights into these findings as reported in this
dissertation. I begin with the assessment of ideas investigated. This is followed by teaching of
the ideas investigated and later by science curriculum on ideas investigated.
Assessment of ideas investigated. As mentioned in Chapter Three, students’ responses to questions on teacher-made assessments of ideas investigated in this research were one of the data sources for this research. In examining the students’ responses, I found that while the teacher-made assessments mirrored closely the intended outcomes of the syllabus (see the section below on the syllabus), the students demonstrated a general lack of conceptual understanding of ideas assessed even on questions at the knowledge level, which is the lowest of the six levels in the Bloom’s taxonomy of the cognitive domain (i.e., knowledge, comprehension, application, analysis, synthesis and evaluation) (Bloom, 1956).

For example, on the chemistry assessment, which had only one question on ideas investigated in this research, the students were required to identify processes involved in the change of state represented by arbitrary letters in the alphabet, on a diagram showing the relationship between the physical states of matter (i.e., solid, liquid and gas), in the first part of the question. The second part of the question required them to name two substances that could undergo sublimation (change from solid directly to gaseous state on heating and vice versa on cooling).

Only two students, Matini and Kayali correctly identified the processes (i.e., melting, evaporation, condensation, freezing and sublimation). Muhonja, Aliviza and Matayo interchanged some of the processes and therefore missed the full credit while Imali failed to identify any of the processes correctly. But when it came to naming substances that can undergo sublimation, none of the students gave the correct name. In fact, some of the students (e.g., Imali, Muhonja and Aliviza) provided processes (i.e., condensation, freezing, melting, evaporation, and sublimation) for responses while the rest (Matini, Kayali and Matayo) gave names of substances that do not undergo sublimation such as oils, ice, zinc oxide and hydrated copper (II) sulfate.
Even though sublimation is not one of the ideas investigated in this research, the inaccurate responses by the students on this part of the question and the first part, for some of the students, clearly show a weak understanding of the ideas being sought. It also shows that it is not just the ideas investigated, in which students demonstrated a weak understanding but other ideas as well.

Based on the responses to this question, the students provided scientific terminologies as responses to parts of the question. They also provided names of chemical substances they may have learned in science. However, the terminologies and chemical names were provided for content where they were inappropriate. Aliviza also provided a scientific terminology for content where it was not appropriate on the physics assessment. To the question requiring the students to state the advantage of lead-acid accumulators over alkaline accumulators she wrote “magnetism” for a response. Both lead-acid and alkaline accumulators are batteries. The difference between them is that, the lead-acid accumulator relies on an acid specifically, sulfuric acid, for an electrolyte (a medium through which reactions within the battery occurs) while an alkaline accumulator relies on an alkaline for an electrolyte. Each of these battery types has advantages and disadvantages that relate to reliability in the supply of electric current, maintenance and cost. In providing magnetism (a phenomenon related to magnets) for a response to the question seeking advantages of a lead-acid accumulator over alkaline accumulator, it shows that Aliviza may have had the scientific terminology magnetism in her mental schema but lacked the conceptual understanding that accompanies the terminology.

The use of scientific terminologies for content where they were inappropriate may mean that the students could have memorized the scientific terms without the accompanying conceptual understanding. These findings coupled with the idea that students adopted everyday language and everyday observations in describing and explaining ideas inherent in the
phenomena investigated in this research point to the likelihood of the students’ inability to cross the cross-cultural border between the everyday culture and that of the science classroom as per figure 1. Based on these findings, the students who participated in this research clearly fit in group X as per figure 1. Thus, even though students adopted scientific language, they did it in ways that did not help them make connections that would lead to effective understanding of ideas inherent in the phenomena investigated in this research.

One way in which students can be helped to develop sound understanding of science ideas they learn in school is to link the teaching to student’s experiences with phenomena and how they might talk about them (Ballenger, 1997; Dotger et al., 2014; Warren et al, 2001). I did not observe the teachers who participated in this research teaching because the ideas I investigated appear in the first and third terms of the school year as per the syllabus and yet I collected data during second term. Therefore it would be inappropriate for me to make conclusive statements and judgments about the teachers’ teaching. However, as mentioned in Chapter Three, I interviewed the two teachers, Evelyn and Chris about their teaching of ideas investigated. In examining the interview transcripts, I found that while both Evelyn and Chris thought that it was important to link science teaching to students’ everyday experiences with phenomena involving the science ideas being taught, there were differences among them not only in the views of what constituted students’ everyday experiences but also how and reasons for incorporating them in teaching science to students. In the following section, I provide Evelyn’s and Chris’s descriptions of their teaching to show how it was unlikely for them to help the students make connections that would enable them not only talk about ideas in the phenomena investigated in scientific ways but also develop sound conceptual understanding of the ideas investigated.
Teaching of the ideas investigated. Both Evelyn and Chris seemed to think that it was important to link students’ science learning to experiences students had with the phenomena outside-the-classroom. However, only Chris, the physics teacher, enumerated several examples of students’ experiences related to the ideas investigated in this research. The examples included dust on windows, shoes, and TV screens even after dusting or wiping them, and sparks from clothing for static electricity and handling of batteries in flashlights and radios for current electricity. Furthermore, he stated that he used those examples in teaching to change the attitudes of the students. Changing the attitudes of students in a given subject is a legitimate goal to be pursued by any teacher. However, focusing on using students’ everyday experiences in doing this could easily obscure the teacher’s view about the same experiences as holding the potential of being connected to the science learned in the classroom involving the phenomena in ways that could leverage students’ science learning. For example, a teacher may fail to pursue how students talk about phenomena involving those experiences in contexts outside the classroom. Such talk as the findings of this research have shown may be different from the one emphasized in the science classroom not just in terms of language (words and phrases) but also experiences or how students come to their understanding of ideas in contexts outside the classroom (i.e., determining the voltage status of batteries and increasing the voltage when determined to be low).

Evelyn, the chemistry teacher, was limited in providing examples of students’ experiences with the phenomena investigated in this research. She gave only one example of an experience she thought was related to the concept of evaporation (i.e., evaporation of puddles after rain) and stated that she relates it to evaporation of a solution in a practical activity (lab
activity). What was even more interesting was her admission that the example given had originated from one of the students in her class. She stated:

There is a student who gave me that example that I told you. Maybe when it rains the water accumulates somewhere, then the following day when the sun shines it is hot the water tends to decrease. In the evening there is no water.

This made me wonder what her examples of students’ experiences with the phenomena investigated in this research were. Evelyn seemed to be more concerned with involving students in practical activities. According to her, practical work helps not only in student’s internalizing scientific concepts but also understanding “faster” as she put it. She stated, “You know, when you incorporate the practical bit of it, the student is able to internalize the concept. And even he or she understands faster than if you avoid the practical, so it is good that you incorporate.”

Evelyn was detailed in describing the practical activities she uses to teach ideas investigated in this research. However, the details were mainly about how she conducts the practical activities using standard laboratory procedures, apparatus and materials. The idea of conducting practical work using standard laboratory procedures, apparatus and materials could have contributed to Evelyn’s concern for things not working as expected. To ameliorate the problem, Evelyn went out of her way to ensure that she conducted the practical activity prior to class time. She stated:

For example, you may perform a practical and maybe it fails something of the sort or a certain apparatus breaks something of the sort so it makes you not get the results that you expected . . . so as a teacher I am forced to do it before the lesson. So I conduct it practically, then after I have achieved the results, I can go back to class and perform a demonstration. And so, by doing that I cut down on these shortcomings that may come in during the experiment.
While it may be important to conduct experiments prior to taking them to class, it is not a sure way that things will work as planned. Furthermore, it may limit the opportunity for exploring other things that may work. Evelyn’s idea of incorporating practical work in teaching is not something that just popped up during the interview. I noted it when I was first introduced to her by the principal as the chemistry teacher I was to interview. After introducing me to all the teachers in the school in the staffroom as someone who was interested in conducting research in the school, the principal asked Evelyn and Chris to accompany he and me to his office so that I could explain the research in more detail to both of them. On that day, the 23rd of May 2013, I noted in my journal, “As soon as we had settled in the principal’s office, I explained to the teachers what the research was all about. Before I requested them to participate in the research, Evelyn said that the students enjoy learning when she uses hands-on-activities.” So when Evelyn described how she incorporated practical work in the teaching of ideas investigated in this research I was able to understand that the practical activities she used were those she conducted relying on standard procedures, apparatus and materials.

As mentioned, it would not be fair to make conclusive statements and judgments about Chris and Evelyn’s teaching without having observed them teaching. However, based on the description of their teaching of ideas involved in the phenomena and activities investigated in this research, both Evelyn and Chris were unlikely to help students make connections between not only their experiences with the phenomena investigated but also how they talk about them and ideas taught in science. This is because they were not familiar with the students’ ways of talking about the ideas investigated. The syllabus is likely to be a contributing factor to this. This is because, as I found after examining the syllabus on objectives and content of ideas investigated, the syllabus is structured. It is not only specific in objectives and content to be
covered but also terminologies students need to develop an understanding of. In the following section, I describe what I found about the syllabus.

The science curriculum on ideas investigated. In examining the secondary school science syllabus (KIE, 2002) with regard to content on ideas investigated in this research, it was clear that the syllabus is specific on objectives and content to be covered. It recognizes the need for students to develop appropriate scientific language to enable them to communicate their understanding of the physical environment as articulated in two of the general objectives for both chemistry and physics: “By the end of the course the students should be able to use the knowledge acquired to discover and explain the order of the physical environment” (KIE, 2002, p. 44) in physics and “By the end of the course the students should be able to use appropriate chemical terms in describing physical and chemical processes” (KIE, 2002, p. 66) in chemistry. The syllabus also makes attempts at linking some of the ideas investigated in this research specifically, evaporation and condensation to their industrial applications: “Applications: fractional distillation of crude oil (e.g., Changamwe oil refinery) and liquid air, salt extraction (e.g., Magadi soda Company and Ngomeni)” (KIE, 2002 p. 68). However, clearly missing in the syllabus were not only examples of phenomena but also possible students’ experiences with those phenomena involving ideas investigated outside the classroom.

The failure of the syllabus to mention examples of phenomena and students’ experiences with them outside-the-classroom contexts serves to possibly mislead and could even reinforce the notion that there is no connection between the science learned in the classroom and students’ experiences with the same science ideas. In addition, it could also lead the teachers into thinking that, students’ experiences with phenomena outside the classroom and in particular how they talk about them is not important.
Chapter Summary

A number of ideas involving phenomena and activities students experience in their everyday lives were investigated in terms of how students talked about them both outside- and inside-the-classroom contexts. The ideas included dissolving (experienced in everyday activities such as addition of salt or sugar to food), evaporation and condensation (experienced through phenomena and activities such as steam forming on roads or rocks following rain on hot day, cooking and dew on grass in the morning), static electricity (experienced through phenomena such as thunder and lightning on a large scale and static cling, shocks when contact is made with objects such as door handles and knobs, and sparks and cracking sounds when undressing especially in the dark with certain kinds of clothing on a small scale) and current electricity (experienced through activities such as phone battery charging and handling of batteries used in radios and flashlights).

The findings in this chapter have demonstrated that the students adopted everyday language (mainly, in the form of words and phrases) in not only describing but also explaining ideas investigated in this research outside-the-classroom context. The same language filtered into discussions about some of the ideas investigated in the inside-the-classroom context. This happened specifically during the discussion of ideas on dissolving where the students adopted the phrases ‘mix well’ and ‘mixed up’ as reasons for stirring the vegetables after adding salt and why the salt could not be seen after water was added to it in a test tube and the test tube and its contents shaken, respectively. It also happened during the discussion on evaporation and condensation where the students adopted the word ‘smoke’ to describe water vapor produced during these processes.
Furthermore, the students relied on everyday observations for their understanding. Thus, in their attempt to explain their ideas involved in the phenomena investigated in this research, the students tended to focus on characteristics and details of the phenomena that were observable but not relevant in helping them make connections leading to effective understanding of the ideas involved in the phenomena. As a consequence, students explained differences in phenomena, even in cases where there were no differences. The reliance on everyday observations as tools for understanding of ideas investigated in this research seemed to have been influenced by students’ experiences with the phenomena involving those ideas.

Additionally, experience seems to have influenced the students’ talking, especially in their choice of some of the words used to describe and explain the ideas investigated in this research. In particular, the experience of clothing becoming wet after passing through an area with overgrown grass containing dew made the students to refer to the substance on grass in picture #3 as water. Likewise, the experience with batteries and how to increase the voltage in a battery after determining that the battery’s voltage was low (i.e., placing the batteries on iron rooftops or near fire) could have been the reason behind one of the students (Imali) referring to voltage in a battery as fire. In the next chapter, I continue answering the same research questions of which I have provided part of the answer in this chapter.
Chapter Five – Findings: Cultural Talk about Lightning and Participation in Discussions

Involving Science Ideas

Introduction

In this chapter, I finalize answering three of my research questions that I began in Chapter Four regarding how students talked about given physical science phenomena in both outside- and inside-the-classroom contexts and how their talking in both contexts were not only similar or different from each other but also to those emphasized in science classrooms. Just as was the case for Chapter Four, the main data I explored to help me answer these questions were transcripts from focus group discussions with students as they engaged in talking about given scientific phenomena, and specifically thunder and lightning. I supplemented these data, with data from transcripts of interviews with two teachers (specifically, Chris, physics teacher), the syllabus on objectives, content and level of treatment of content involving ideas investigated in this research and the students’ responses to questions involving ideas investigated.

Just as was the case with other phenomena investigated in this research I cued students to experience the phenomenon of thunder and lightning by having them watch a video – in this case the video #6 of a thunderstorm on my laptop before commencing their discussion. I found that the students adopted a cultural talk about lightning related not only to the nature and form of lightning but also many dos and don’ts during a thunderstorm. The cultural talk also involved the students’ talk about what would happen if the don’ts were not adhered to and the first aid to be given to a victim of a lightning strike. This talk which is significantly different from that emphasized in science classrooms seems to have been acquired through interactions with other members of the community, including family members and peers. Besides the cultural talk, I also found that it is during the discussion on thunder and lightning that one student, Imali, showed her
ability to participate and engage in a discussion. Her participation during the other discussion sessions was not as pronounced. Thus, these findings are uniquely different from those I have described in Chapter Four and this is the reason why I have described them in a chapter of their own.

In the following sections, I describe the patterns in students’ talk starting with the nature and form of lightning. This is followed by safety against the effects of lightning. I also highlight Imali’s participation during the discussion on thunder and lightning under the heading participation in discussions involving science ideas. Additionally, just as was the case in Chapter Four I draw on data from the interview with Chris (the physics teacher), the syllabus and the students’ responses to questions on teacher-made assessments to relate the students’ talk to teaching, the science curriculum and assessment of ideas investigated. Thereafter I provide a summary of the chapter.

The Nature and Form of Lightning

Lightning is a natural phenomenon that is often accompanied by thunder; hence the phrase thunder and lightning. It is a large scale representation of real-life phenomena such as static cling, cracking sounds and/or sparks when undressing with certain kinds of clothing (e.g., those made from polyester) especially in the dark and “shocks” experienced from handling car door handles or door knobs. The phenomenon of thunder and lightning is certainly more complicated than I may represent it here, but basically the starting point of thunder and lightning are moving clouds. Clouds are believed to be neutral (they have equal number of positive and negative charges). However, as the clouds move and rub against each other, one set of clouds may transfer some of its negative charges to the other set of clouds. This results in the two sets of clouds carrying opposite charges. This is because the cloud that will have transferred some of its
negative charges will be positively charged (having more positive charges after the transfer of some of its negative charges) while the one that will have received the negative charges will be negatively charged (having more negative charges after gaining some negative charges from the other cloud to add to its own negative charges). If clouds having opposite charges happen to come in close proximity with one another, a force of attraction that results in lightning occurs. The force of attraction between the clouds is accompanied by both sound and light. Since light travels faster than sound, light is often observed before the rattling sound during a lightning bolt.

Lightning can also occur when two oppositely charged clouds are not involved. A charged cloud formed as mentioned above, potentially charges the Earth with an opposite charge to the one being carried by the cloud. If the Earth is charged such that it carries a negative charge, then the negative charges are pulled above the surface of the earth upwards towards the sky through objects that can conduct electric charge such as trees and people and accumulate at the top most tip of the object. The taller the object, the higher the charges are up towards the sky from the Earth’s surface. A force of attraction between the clouds’ charges and those at the tip of the nearest tallest object (e.g., people, trees) may occur that results in lightning striking the object or person. Thus, lightning is known to have devastating effects since through a strike such as the one described above, it can cause damage to property that include houses through fires, and injury or even death to people and animals (both domestic and wild). The damage or death occurs because lightning is usually accompanied by huge amounts of voltage. The idea that lightning strikes the Earth through the nearest tall object is the reason behind the general advice to people to avoid open fields or taking shelter under a tree during a thunderstorm.

How people explain the phenomenon of lightning has been investigated (Pauka et al, 2005). Pauka et al. investigated village elders’ and high school students’ explanations of natural
phenomena, including rainbow, thunder and lightning, and erosion in Papua New Guinea. The researchers collected data through interviews with the elders and student questionnaires. They found that the village elders provided explanations for the occurrence of the phenomena that included spirits, spells, magic and religion. While some students provided explanations for the occurrence of the phenomena based on school science, there were some who gave explanations such as those of the village elders.

In this research, after the students watched the video of a thunderstorm, they talked of several dos and don’ts when it is raining and the rain is accompanied by thunderstorms as they addressed, questioned and completed each other’s sentences. Indeed, it is during the discussion on thunder and lightning that I talked the least. I only joined in their discussion when I sought clarification on some of the ideas discussed. The students even talked of how they had put to test some of the ideas arising from the talk. Among the things students talked about that should be avoided during a thunderstorm was noise. They even anthropomorphized lightning by stating that it does not like noise. For example, Imali stated, “Also, you are not supposed to make noise while inside the house. You need to be silent . . . it doesn’t like a lot of noise.” Aliviza and Muhonja supported her idea of the need for silence during a thunderstorm and also anthropomorphized lightening. Aliviza started the sentence, “If the rain is a lot . . .” and Muhonja completed it “. . . it doesn’t like it when it is too noisy.” But there was more to noise than not “being liked” by lightning. It came out that noise would make lightning to appear in the form of a red rooster that would then attack people. The following is the students’ conversations with regard to noise and the appearance of the red rooster during a thunderstorm.

Yohana: Some time back we used to be told that if we make noise, there is a rooster that comes through…(inaudible).
(Laughter)

Yohana: So it is the rooster that makes us not to make noise.

Researcher: Where does the rooster come from?

Yohana: The older people used to tell us that if one makes noise the rooster could come and beat you…

(Laughter)

Kayali: What I heard is that if you walk in the water when it is raining and lightning is about to beat you, it starts with you seeing a red rooster.

Researcher: A red rooster?

Students: Yes.

Researcher: And, Yohana what color is the rooster you talked about?

(Laughter)

Yohana: I have never seen but I just heard that it comes through the rain.

Researcher: You just heard. And it is good to talk about things we have heard. Isn’t it?

Students: Yes.

Researcher: So the noise makes the rooster to come?

Students: Yes.

Aliviza: Even me, I heard it is a red rooster, because they say that if you are wearing a red dress and walk outside when it is raining, lightning can burn you.

Muhonja: It is not a must.

Imali: I also support that one of the red dress. For example, if it is raining and I have put on a red T shirt, I will be asked to remove it as fast as I can.

Researcher: And do you remove it?
Imali: Very quickly, in fact.

The rooster idea and red clothing were readily dismissed by Muhonja as “beliefs.” She claimed that she had even put to test some of the ideas talked about by the students, specifically being outdoors with a red umbrella during thunderstorms, but she was not ‘hit’ by lightning. She stated:

But those are just beliefs. Because people talk about the umbrella like [Yohana’s second name] talked about and particularly if it is red, that you can be hit by lightning. But that thing I have tried. I went to the shop with a red umbrella but I was not hit by lightning.

What Muhonja demonstrated through this statement is that ideas should not just be accepted. Rather, they should be put to test through experimentation. Even though Muhonja’s experiment may not be considered an experiment in the scientific sense of the word, the way she proceeded was similar to how earlier scientists (e.g., Marie Curie (1867-1934) and her husband Pierre (1859-1906)) proceeded with their investigations for understanding about given phenomena. Marie and Pierre were the first scientists to conduct investigations into the phenomenon of radioactivity (Mullner, 1999). In conducting their investigations, they were oblivious to the danger they exposed themselves as they undertook investigations on radioactive material – pitchblende to isolate radium and polonium (both radioactive elements) from it. Besides working without protective gear, they often tested the effects of the products of their isolation on themselves. For example, after reading a report about a researcher who had experienced burns from handling tubes containing radium:

Pierre Curie decided to test radium effects himself. He took a small amount of the element and strapped it to his arm and left it there for 10 hours. When he removed it, Pierre found the area under the radium had turned red. (pp 9-10)
Even though Pierre died following a traffic accident, he had started experiencing health problems associated with radiations from radioactive materials that he and his wife handled. Marie died from an anemic condition due to her exposure: “Her bone marrow destroyed by her many years of exposure to radium” (p. 13). But more important is the idea that the failure of Muhonja’s experiment led her to the conclusion that ideas being talked about with regard to thunderstorms were mere “beliefs.” How one goes about conducting an experiment is as important as the results, and this is the message Kayali and Imali had for Muhonja as shown by their conversation that follows:

Imali: Maybe the rain was not a lot.

Kayali: And also you did not step in the water as you walked. If you have that umbrella and then you walk through the water, you will just see the red rooster and you will be attracted together with that red umbrella.

Imali and Kayali speculated on why Muhonja’s experiment failed. I could also imagine them and other participants being speculative with things such as “maybe you were wearing shoes or you were not holding onto the metal part of the umbrella” as reasons why the experiment failed. What Imali and Kayali talked about here are variables (factors in an experiment that can be controlled or manipulated). They may or may not have viewed them as variables but what is clear from their statements is that before making conclusions based on experimental results, one needs to exhaustively investigate and manipulate all the variables associated with the experiment. The conversation between Muhonja, Imali and Kayali shows that they had a scientific mind set (i.e., putting ideas to test and checking to ensure all variables involved with the ideas are manipulated). It also shows the strength with which students can hold onto their ideas acquired from outside-the-classroom contexts (i.e., from family and peers). I
note this because of Imali’s and Kayali’s responses to why Muhonja’s experiment failed. Based on their responses, lightning is indeed a red rooster that “attracts” (to use Kayali’s word) people when they go outdoors during a thunderstorm dressed in red. Thus, this conversation helps to raise questions on how students having ideas such as those of Imali and Kayali can be helped to build upon them to further their understanding in science.

Regarding the red rooster and red clothing, I do not understand the origin of these ideas although I had also heard about them while I was growing up. It was therefore surprising even after more than 40 years the same ideas have persisted. This means that these ideas are firmly rooted in the belief system of the Maragoli and Bunyore people. However, in my own thinking, a rooster is a symbol of power. This may be the reason why it is used as part of the emblem of the Kenya African National Union (KANU), the party that ruled Kenya for close to 40 years from the time of its independence in 1963 to 2002 when the party was voted out. In the emblem, the image of a red rooster on a white circular background is positioned in the middle of a rectangle with colors of the national flag, black, red and green (at the top, middle and bottom, respectively) running across it. A rooster is also part of Kenya’s court of arms. In the court of arms, the image of a white rooster holding onto an axe against the background of a shield appears to be marching forward. It probably symbolizes a new dawn for Kenya and ready for attack (see the axe it is holding onto) should an enemy strike. For KANU’s emblem and Kenya’s coat of arms see Appendix G.

In real life, a rooster is known to be a fighter. It does not allow other roosters to come near its territory, especially when hens are around. In fact, it is rare to find a family keeping more than one rooster on its farm because of the fights that are likely to erupt between the roosters. Even though a rooster may not attack people, its use as the nature and form of lightning by the
Maragoli and Bunyore people may have been intended to have, especially the youngsters, have an image firmly in their mind of something that is dangerous, that has power to alter one’s life forever and therefore something that should be avoided by all means. It may have been done to help control the behavior of not only venturing outdoors during a thunderstorm by young people but also ensuring that while inside the house there was order or “silence” as Imali put it. Growing up and seeing how roosters fight each other, youngsters would probably be afraid to imagine lightning attacking them in a similar manner. The dangerous nature of lightning was evident in the variety and nature of verbs used by students to describe it after watching video #6 of a thunderstorm.

Generally, lightning is talked of as having the ability to strike people or things. But this was not a terminology that was part of the students’ language as they talked about lightning. Rather, they talked of lightning as having the ability to ‘hit’, ‘beat’, ‘find’, ‘pass with’ and ‘burn’ people or things as exemplified by the following conversations by some of the students. Imali, in reference to how people should conduct themselves during a thunderstorm stated, “It is also said that when there is such rain, one is not supposed to be outside because the lightning can hit you.” Yohana, in reference to a pointed umbrella handle stated, “lightning can pass through it and find you.” Matini, in referring to an umbrella’s handle stated, “It [lightning] can only beat you if you are holding onto the metal part but they have put there whatever, it prevents that from traveling. So when you hold it and it has it, it cannot beat you.” Imali, in reference to parts of the house that should be avoided, stated, “If you are inside the house you are not supposed to be near a corner. The lightning can pass with you.” And Aliviza, in reference to the color of clothing when outdoor during a thunderstorm stated, “They say that if you are wearing a red dress and you walk outside as it is raining, lightning can burn you.” The verbs, ‘hit’, ‘beat’, ‘pass with’, ‘burn’, and
‘find’ used in describing what lightning can do, all point to something that is dangerous and one that should be avoided.

The idea of behavior control seems to be of paramount importance and one that may have arisen from the need for safety from the effects of lightning. This is because students talked of several places and things to avoid during a thunderstorm failure of which would result in one being ‘hit,’ ‘beaten.’ ‘passed with,’ ‘burned’ or ‘found’ by lightning. In the following section, I describe the students’ talk about places and things to avoid and what to do to a victim of a lightning strike.

**Safety Against the Effects of Lightning**

The need for safety during a thunderstorm was clear in the students’ conversations about thunder and lightning. They talked of places and things that should not only be done, but also avoided during a thunderstorm. Among the things to be avoided was being outdoors, and in particular, carrying an umbrella, and while inside the house, corners and walls of the house were to be no-go-zones as shown by the following conversation.

**Imali:** It is also said that when there is such rain one is not supposed to be outside because the lightning can hit you. And if you are in the house you are not supposed to be at the corner of the house. You are just supposed to be . . .

**Researcher:** You are not supposed to be at the corner?

**Imali:** Yes at the corner, or . . .

**Aliviza:** . . . lean on the wall

**Imali:** Yes. Lean on the wall. Also, if such rain happens to find when you are walking you are not supposed to step in the water. It can . . .

**Aliviza:** . . . beat you
From the students’ talk, there were concerns for people to be safe from the effects of lightning. But the concerns were not just about people’s safety. There were concerns also for the safety of property, such as houses. The students talked of avoiding the use of firewood from a tree struck by lightning because it would result in lightning burning down the house. However, Kayali stated that the wood could be used but that a precautionary measure of licking the ash from the wood after its use was necessary. The following is the students’ conversation with regard to a tree struck by lightning and its use as firewood.

Researcher: OK, and when [lightning] hits a tree, what happens to the tree?
Students: It dries.
Researcher: Then?
Yohana: It just becomes firewood.
Kayali: I have heard that if lightning has burned a tree (*laughs*), you are not supposed to use it as wood or if you do, you must lick some of the ash

(*Laughter*)

Kayali: The wood can blow up . . . (*laughs*).

Researcher: It is that interesting?

(*Laughter continues*)

Yohana: It is said that *umeme* (Kiswahili for electricity) can pass through your . . .

(*inaudible*).

Kayali: . . . then it blows up the house.

Researcher: After you have used the firewood to cook you need to lick the ash?

Students: Yes

Researcher: Is that so?

Kayali: So that lightning does blow up the house. (*laughs*)

Kayali’s initial idea was that the use of wood from a tree struck by lightning can lead to the wood blowing up the house but later changed to lightning blowing up the house following Yohana’s interjection in the conversation where he referred to lightning as *umeme* (Kiswahili for electricity).

Despite all the concerns and precautionary measures for guarding against the effects of lightning, it emerged that possibilities existed of someone being ‘hit’ or ‘beaten’ by lightning. In the event that such a thing happened, Imali stated that giving raw eggs to the victim would help save the person’s life. However, she was categorical that timing was the determining factor between life and death for the victim, as shown in the following conversation.

Imali: And if you have been hit by lightning, you are supposed to drink eggs.
Muhonja: What about if it has hit you and you are dead?

Imali: That is the problem, but if it hits you and they are aware of it, they should give you eggs on the spot.

Aliviza: Raw or cooked?

Imali: Raw.

Yohana: It is said that if lightning hits you, you become its path no matter where you hide. When it rains it will pass through you.

Imali: That would be bad luck, but if it hits another person s/he is supposed to be given eggs.

This conversation on safety against the effects of lightning, and others before it, in particular the idea of lightning being in the form of a red rooster, reveal that students talked of thunder and lightning in ways that were significantly different from those emphasized in school science. As mentioned earlier, the science behind lightning is one where lightning occurs as a result of the attraction between oppositely charged clouds or between charges in one set of clouds and opposite charges from the Earth through objects such as trees. This then raises the question of how students’ alternative understanding and talking about a phenomenon such as lightning can be reconciled with school science. This question is even more critical especially when the students’ talk is accompanied by inaccurate ideas about the phenomena, as was the case during the discussion on thunder and lightning.

Most of the students’ understanding and talk about lightning, its nature and form, and the dos and don’ts during a thunderstorm arose from what they had heard or been told by family members and peers since it was characterized by statements such as “I am told . . .” and “It is said that . . .” For example, Yohana admitted that he heard about the red rooster from his
grandmother. To the question of whether or not he had seen a red rooster during a thunderstorm, he responded, “No I have never seen, but I was told by my grandmother.” However, when I asked the students to talk about what they thought was the cause of lightning and what makes lightning harmful, Yohana talked of light as the thing that harms people when struck by lightning. He stated:

The thing that harms a person when lightning appears is the light. That light is more powerful than sound because sound comes last . . ., but with light, the moment it lights you up, it has already passed and it has already harmed you.

Just like sound, light is the result of the lightning phenomenon. However, since lightning and the accompanying sound and light happen within microseconds of each other, with light appearing first because of travelling faster than sound, it becomes difficult to separate them. This could be the reason why Yohana had the idea that light is the thing that harms someone when struck by lightning. Similarly, Muhonja had an understanding that to be struck by lightning depended on the “kind” of rain. She stated:

It depends on the kind of rain, if it is one with a lot of lightning and thunderstorms are rattling, that one you cannot come out of the house. But if it is one with little whatever, lightning cannot beat you.

I assumed that the word whatever in Muhonja’s statement meant lightning and thunderstorms, based on the first part of her sentence. The striking by lightning was dependent on, among other things, the path it is travelling and height of the object, but may not be dependent on the “amount” of lightning and thunderstorms as Muhonja had alleged. Indeed, cases have been reported where people, animals or other objects have been struck by lightning even when there was no rain. Based on these examples of accurate and inaccurate understanding about thunder
and lightning, coupled with the talk about lightning that is significantly different from that emphasized in the science classroom specifically, its nature, form and what it can and cannot do, it becomes necessary for a reconciliation of the understandings with school science.

**Participation in Discussions Involving Science Ideas**

Participation in science learning and specifically, discussions involving science ideas by students whose home culture seems to be significantly different from that of school science is a question that has been examined by scholars (Ballenger, 1997; Warren et al., 2001). Through the work of these researchers it has been shown that it is possible for students whose culture is significantly different from that of the science classroom to participate and engage meaningfully in science learning and in particular discussions involving science ideas. According to these researchers, students’ ways of making sense, including their first language, are tools for such participation and engagement. They argued that through the students’ first language, the students are enabled to bring their personal experiences and ways of talking and acting to the science task and that although the students may initially start by talking about ideas in ways that may not look scientific, the students eventually shift in their thinking and talking using scientific language (Warren, 2001) and asking questions that can be investigated scientifically (Ballenger, 1997).

In this research and as mentioned in Chapter Three, the students used two languages for their discussions about ideas inherent in the phenomena investigated – Kiswahili for the discussions outside-the-classroom context and English for the inside-the-classroom context. As mentioned in Chapter Three, Kiswahili is not the first language of these students, but its status as a national language has enabled the general population to develop proficiency in most aspects that go with a language including reading, writing and speaking. In addition, it is taught in school as a language. In listening and watching the recorded sessions for both the outside- and inside-
the-classroom contexts, I found that compared to the discussions conducted in English, those conducted in Kiswahili were livelier and the atmosphere was more relaxed. However, the discussion on thunder and lightning was extraordinary. As mentioned earlier, I cued students before engaging in the discussion about thunder and lightning. I used video #6 of a thunderstorm for that purpose. Following the watching of the video, I asked them to talk about what they had observed in the video and to state and explain why things happened that way. The discussion that ensued was animated and characterized with laughter. Unlike other discussion sessions, the discussion on thunder and lightning was the only one where students engaged each other in proposing ideas, questioning each other, and seeking clarifications from each other. I only joined in the discussion when I needed a clarification on something the students said that was not clear.

While most of the students participated equally in the discussion, Imali, who had struck me as a student who was not interested in making contributions during the other discussions, stood above the rest of the students during this discussion. She had adopted a passive stance during the discussion sessions of ideas other than thunder and lightning. She only talked when I asked her for her opinion on what was being discussed by the other students and her answers were very brief. They included phrases such as “I don’t have anything to add”, and “I agree.” However, during the discussion on thunder and lightning, Imali volunteered information not only on the dos and don’ts in the event of a thunderstorm, but also first aid to be administered to a victim of thunderstorms in addition to speculating on why Muhonja’s “experiment” had failed. I have already described these in this chapter under the nature and form of lightning and safety against the effects of lightning. However, this level of participation in the discussion by Imali helps to raise the question of why a student who has not been participating in a discussion on science ideas suddenly begins to participate. This is a question I return to in the discussion.
section in Chapter Six. However, it seems clear that, based on Imali’s example, a student perceived to be quiet while others make contributions during a discussion involving scientific ideas should not be interpreted to mean that the student has a weak understanding in science or that the student has nothing to say. Rather, the question that should be asked is what can be done to devise ways and opportunities that can enable students such as Imali to not only engage but also participate meaningfully in science learning and in particular, discussions.

**Students’ Talk in Relation to the Science Curriculum, Teaching and Assessment of Ideas Investigated**

The findings of this research as described in this chapter show that the students talked about lightning in a way that is significantly different from that emphasized in science classrooms. They not only talked of many dos and don’ts but also, lightning being in the form of a red rooster that can attack people especially, if they made noise during a thunderstorm. This talk about lightning was cultural, mainly arising from the students’ interactions with other members of the community. In addition, through this talk, some inaccurate ideas about lightning were conveyed. In the following section, I relate these findings to assessment, the science curriculum and the teaching of ideas investigated by drawing on the data from the transcripts of the interviews with Chris, the syllabus, and students’ responses to questions on teacher-made assessment of ideas investigated in this research. In doing so, I aim to connect the findings to the frameworks that guided this research.

The science curriculum, the teaching and assessment of ideas investigated. Thunder and lightning is an example of a phenomenon involving the idea of static electricity. Given that the students talked about lightning in ways that are different from the ones emphasized in the classroom, it calls for ways of integrating the cultural talk about lightning with scientific talk for
purposes of leveraging them to learn the science involved in effective ways. This is crucial because the students also conveyed some inaccurate ideas through their talk. Furthermore, some of the terminologies used during the focus group discussions were also evident in some of the responses on the teacher-made assessments. For example, to a question requiring the students to explain why it was dangerous to seek shelter under a tree from rain, some of the verbs (e.g., hit and burn) used during the focus group discussions to describe what lightning can do to people or things featured in the students’ responses. Thus, these findings reveal not only how stable but also the ability of everyday language to filter and influence student’s thinking in science.

Everyday language, and particularly its stability with regard to understanding some terminologies as applied in the context of science, has been documented (McNeill, 2011; Ribeiro et al, 1990). The findings of this research are thus consistent with those of studies conducted by these scholars with regard to stability of everyday language across contexts (i.e., everyday and the science classroom) and over time.

The idea of cultural talk about lightning that is significantly different from that emphasized in the science classroom coupled with responses to questions on teacher-made assessments reflecting cultural talk about lighting seem to position the students in their everyday culture side of the cultural border as per figure 1. In other words, based on these findings the students clearly belong to group X in the same figure.

One way of integrating the cultural talk with school science is for the syllabus to be explicit in naming thunder and lightning as an example of phenomenon involving the idea of static electricity and acknowledge that there could be cultural talk in outside-the-classroom contexts related to it. As mentioned in Chapter Four, the syllabus is silent on thunder and lightning just as it is on other phenomena such as static cling, as examples of phenomena
representative of static electricity. The failure of the syllabus to be explicit on thunder and lightning as an example of a phenomenon representative of the idea of static electricity effectively separates science ideas in class and the students’ experiences with the phenomenon involving those ideas. It also conveys a wrong message of there being no need to link students’ learning and experiences outside-the-classroom and much less to any cultural talk that students may have.

Furthermore, a teacher may know that there is cultural understanding and or talk about ideas being taught in class and even make an effort of talking about it with students. However, without something on which to base his or her action, s/he may end up dismissing the knowledge as not being important as was the case with Chris, the physics teacher I interviewed. Chris acknowledged that the students had understanding about lightning as something that can be manipulated by someone for purposes of harming other people and further stated that students viewed people who had the power to manipulate lightning as belonging to a religion of witchcraft, “so some of them know that there is a religion of witchcraft so where those who can make thunder and lightning belong to.” He mentioned that he makes an effort directed at helping the students understand that there is a correlation between religion and science but emphasized the scientific part because it is the one required for examination. He stated:

So I usually explain to them . . . that sometimes religion and science correlate. So sometimes science can help in explaining religion and also religion can explain some science. So it is good they should be knowing both the religious part of it and also the scientific part. But I emphasize on the scientific part because right now the scientific part is the one that is required in answering the questions, but not those mythical thinking they usually use.
It is interesting to note that although Chris would want students to understand that there is a correlation between religious knowledge and scientific knowledge, he dismisses the students’ ideas as being mythical thinking and goes ahead to emphasize the scientific knowledge. The idea of dismissing students’ ideas as being mythical thinking may arise from the fact that there is nothing to support him to think otherwise. Furthermore, raising the status of scientific knowledge in the face of other forms of knowledge about the same phenomena for purposes of examination is likely to be counterproductive and could lead to superficial learning and memorization of scientific terminologies just to pass examination such that when the pressure of exams eases, the students forget and retreat to their earlier understandings.

Chapter Summary

Given the nature of thunderstorms and how they occur, it was not possible to conduct a demonstration such as those conducted with other phenomena to illustrate it and therefore enable students to talk about it for the inside-the-classroom context. Thus, there was no discussion of thunder and lightning for the inside-the-classroom context to compare with the outside-the-classroom context. However, the findings in this chapter have demonstrated that there was a difference in the way students who participated in this research talked about thunder and lightning phenomenon outside-the-classroom context and how it would be talked about in a science classroom. A thunderstorm is a natural phenomenon that is common during rain. It occurs as result of attractive forces between oppositely charged clouds or between a charged cloud and the Earth through the nearest tall object such as a tree. In science, these forces are referred to as electrostatic forces and are part of concepts learned under the idea of static electricity.
In discussing about thunder and lightning, the students talked of many do and don’ts during a thunderstorm that included avoiding making noise. According to the students, noise during a thunderstorm would make lightning to appear as a red rooster that would then attack people. Clearly evident from the students’ talk about dos and don’ts during a thunderstorm was the concern for safety, not only for people but also property such as houses. The students recognized that even with all the don’ts during a thunderstorm, a possibility existed of someone being struck by lightning and therefore in the event that such a thing happened, it was clear from the students’ talk that there was first aid to be administered to the victim of a lightning strike. The first aid involved giving the victim raw eggs.

Most of what the students talked about were things they had heard or were told by members of their families (e.g., grandparents) and peers mainly because of their characteristic sentence beginnings such as “I am told . . .”, “It is said that . . .” or “I have heard that . . .” However, in seeking the students’ own understanding of the cause of lightning and what it is that harms people when struck by lightning, I found that their talk also included inaccurate understandings about lightning. This, therefore, calls for a bridging in the talk between school science and everyday talk of phenomena such as lightning. Lastly, the findings in this chapter show that possibilities exist for students who may seem uninterested in participating in a discussion involving scientific ideas to engage and participate in such a discussion as shown by the immense participation by Imali during the discussion on thunder and lightning.

This chapter marks the end of answers to the first three of my research questions. In the next chapter I discuss the findings of these research as well as implications for these findings in teaching and learning science.
Chapter Six – Discussion, Implications and Conclusion

Introduction

There are three main findings that emerged through this research. The findings are: (1) the adoption of everyday ways (i.e., everyday language and everyday observations) by the students in talking about ideas investigated both outside- and inside-the-classroom contexts, (2) the emergence of cultural knowledge about the nature and form of lightning different from that emphasized in school science and (3) the existence of possibilities for participation in discussions involving ideas in science by students who may seem initially uninterested. I have described these findings in detail in the Chapters Four and Five of this dissertation. In this chapter, I discuss these findings in relation to literature involving students learning science in a language other than their first language. In addition, I discuss the implications of these findings in the teaching and learning of science by SLSL2 in an endeavor to answer the fourth and last research question about implications for how the students talked about ideas investigated in both the outside- and inside-the-classroom contexts. Lastly, I provide a conclusion of this research and offer some recommendations and areas for further research. I start with a brief discussion of the limitation of this research.

Limitation of this Research

This research sought to determine how secondary school students talk about ideas involved in physical science phenomena. It involved selected Form Two students from a public, day, mixed gender secondary school from the Maragoli community of Western region in Kenya who engaged in talking about ideas in selected physical science phenomena both outside- and inside-the-classroom contexts. The study also involved two teachers (one for chemistry and one for physics). The first limitation of this research is with regard to the number of phenomena
investigated. The phenomena investigated are those that I perceived to be likely encountered by students both in the classroom and outside the classroom. This case study approach makes the findings of this study limited in terms of scope and generalizability.

The second limitation has to do with the nature of the phenomena investigated. This research relied on phenomena that could easily be simulated albeit vicariously (i.e., through videos, and pictures) and hands-on activities for both the outside- and inside-the-classroom contexts. Science involves numerous ideas students learn about in the classroom which may be difficult to conceptualize in everyday contexts. Such ideas include the atom and atomic structure, bonding, and radioactivity, just to name a few. Thus, while it may be important to gain insights into how students talk about such ideas in an outside-the-classroom context it would be challenging to simulate phenomena involving these ideas in ways similar to the ones employed in this research because of the abstract nature of the ideas and the seeming little experience with phenomena involving these ideas in an outside-the-classroom context.

The third limitation is related to the venue where I conducted the focus group discussions and the language used during the discussions for the outside-the-classroom context. As mentioned, I conducted focus group discussions in school mainly because of the need to have a venue that was convenient both for me as the researcher as well as the students. I asked the students to use Kimaragoli, their first language during discussions for the outside-the-classroom context but they said that they preferred Kiswahili. The school compound could have influenced the students in choosing Kiswahili as their preferred language. This is because some schools insist that students either speak English or Kiswahili in school. Thus, while there may be several options of venues I could have chosen to conduct the focus group discussions (i.e., church compound, market place, roadside, my home), I cannot be sure how these venues would have
impacted not only the choice of language for the outside-the-classroom context but also the findings of this research.

**Discussion**

In this section, I discuss the findings of this research in relation to literature on science learning involving SLSL2 under the headings everyday ways of making sense of the world and science learning, cultural knowledge on thunder and lightning and science learning and participation in discussions involving science ideas.

**Everyday ways of making sense of the world and science learning.** The students who participated in this research were in Form Two at the time of data collection. Form Two is the second of the four classes (years for U.S.) at the secondary school level in Kenya. I expected that the students had already learned the ideas investigated in this research given that the ideas were part of physics and chemistry content for the Form One course, according to the syllabus. Thus, I had anticipated that the students would talk about these ideas in scientific ways – those that employed scientific terminologies and explanations especially, with regard to the inside-the-classroom context. However, the findings of this research show that the students adopted everyday ways of talking about ideas involved in the phenomena investigated in this research, both outside- and inside-the-classroom contexts. The everyday ways, which included not only the language but also a reliance on everyday observations for the explanations of ideas inherent in the phenomena and activities investigated, are significantly different from those emphasized in science classrooms.

It then seems accurate to suggest that even though the students had learned the science behind the occurrence of the phenomena investigated in this research, the learning had no impact in helping them view and talk about the ideas learned in scientific ways. This is particularly the
case because the students demonstrated a general poor understanding of ideas involving the phenomena investigated in this research on teacher-made assessments, even on questions at the knowledge level which is the lowest level, in the Bloom’s taxonomy of the cognitive domain (Bloom, 1956).

Everyday ways of making sense of the world, including everyday language, are tools available to students in their everyday lives given that they are the ways and language through which they experience and perhaps talk about the phenomena. Also, given that Kiswahili, which is the language used during the discussions outside-the-classroom context, is only taught in school as a language, it may not be possible for students to be conversant with Kiswahili content-related terminologies in the various subjects in the school curriculum including science. However, in adopting everyday ways in talking about the phenomena investigated in this research, especially in the inside-the-classroom context may mean that the students’ were unable to make connections that would enable them not only view but also talk about the ideas in scientific ways. This may have resulted from teaching that did not help the students to make connections between their everyday understanding of the phenomena and the science behind the occurrence of the phenomena.

There are a number of ways in which connections between everyday ways of making sense of the world and scientific ways for students can be made. First, the curriculum materials, such as the syllabus, need to be explicit in not only providing examples of everyday experiences with phenomena related to a given content, but also provide guidance on how students’ experiences can be connected to the science ideas involving those experiences. This way the teachers may not only see the need for, but also make attempts at linking those experiences to science ideas taught in the classroom. Second, even if the syllabus made explicit attempt to
linking students’ experiences with phenomena with the science content involving those phenomena, the teachers need to not only be aware of students’ everyday ways of making sense of the world, but also have the abilities to help the students make the required connections.

Based on the description of their teaching of ideas involved in the phenomena and activities investigated in this research, both Evelyn and Chris were unlikely to help students make connections between their experiences with phenomena in outside-the-classroom contexts together with the associated talk about them and ideas involved in them as taught in science. In other words, they were unlikely to create third spaces as per figure 1. As mentioned in Chapter Three, Moje et al (2001) recognized that students come to the science classroom with everyday ways of making sense of the world. They referred to these ways as “social or everyday Discourses” (p. 471). According to Moje et al., the creation of third spaces is a necessary step towards helping students to integrate their everyday ways of making sense of the world with those of the science classroom. They characterized third spaces as involving classroom interactions where there is:

(a) drawing from students’ everyday Discourses and knowledges, (b) developing students’ awareness of those various Discourses and knowledges, (c) connecting these everyday knowledges and Discourses with the science discourse genre of science classrooms and of the science community, and (d) negotiating understanding of both Discourses and knowledges so that they not only inform the other, but also merge to construct a new kind of discourse and knowledge. (p. 489)

Based on this, it is clear that such interactions not only place the teacher squarely at the forefront, but also demand for teachers to be familiar with the students’ everyday ways of making sense of the world in order to initiate and sustain discussions involving them in a classroom set up. This is
particularly so if teachers are expected to be effective “cultural brokers” (Aikenhead, 2001). This then brings me to the question of how students such as the ones who participated in this research could be helped to negotiate the cross-cultural border between their everyday ways of making sense of the world and that of the science classroom.

Everyday ways of making sense of the world, including students’ first language, have been shown to be useful tools of meaningful engagement in science learning, especially by students whose everyday culture is significantly different from that of the science classroom (Ballenger, 1997; Warren et al., 2001). For example, in a study conducted by Ballenger involving students whose first language was Haitian Creole, Ballenger found that the students used Haitian Creole and brought their personal experiences with bathrooms and materials for cleaning them in talking about a scientific task – mold growth. Ballenger argued that the students who participated in her study engaged in meaningful learning because at the end of the discussion, they were able to raise important questions that could be investigated scientifically. She observed of one student called Joanne, “Science in schools often ends up with knowledge like, water is necessary for mold to grow. What Joanne is asking is how? (p. 10). The how question is an important one, particularly in science because it helps in moving students beyond accepting ideas at their face value into thinking about ways investigations can be conducted to further their understanding.

The students who participated in this research used Kiswahili (the language used in contexts outside the classroom by the majority of people in Kenya given its status as the national language and only learned as language in school) and engaged in talking about ideas inherent in the phenomena and activities investigated in an outside-the-classroom context. They adopted everyday language including, words and phrases that clearly were everyday words given the
language they used in talking and the unlikelihood of them developing sound science understanding in the language. These terminologies filtered into conversations about the ideas investigated in the inside-the-classroom context for some of the ideas. The ideas include dissolving in which the students used the phrase ‘mix well’ for the reason the why the vegetables were stirred after adding salt outside-the-classroom context and ‘mix up’ for the reason why the salt in a test to which water had been added and shaken could not be seen in the inside-the-classroom context. The students also adopted the word ‘smoke’ to describe water vapor formed during evaporation outside-the-classroom context and evaporation and condensation in the inside-the-classroom context. The students also adopted words and phrases in describing and explaining other ideas investigated (i.e., static electricity and electric current) outside-the-classroom context even though those words and phrases did not filter into conversations in the inside-the-classroom context. For example, they adopted the words ‘sticks’ and ‘fire’ for attraction between opposite charges and electricity or voltage, respectively.

As mentioned earlier, there may be nothing wrong in adopting everyday language to talk about ideas in phenomena in science outside-the-classroom context given that that is the language in which the students experienced the phenomena and talked about the phenomena. But when it comes to the science classroom, students need to adopt scientific ways, including the scientific language, to talk about and explain the science ideas. In other words, the students need the language to enable them to talk science (Lemke, 1990). Teachers can help the students acquire this language. For example, the words and or phrases students use to describe ideas inherent in phenomena as experienced outside the classroom can be a good starting point.

The idea of starting from everyday language has been shown to help students gain proficiency in using content related language (Herbel-Eisenmann, 2002). Herbel-Eisenmann
described case studies of two teachers and their students in eighth grade she observed teaching mathematics (specifically, algebra). Herbel-Eisenmann argued that the teachers successfully helped the students to adopt mathematical language related to algebra by drawing on students’ everyday language and ideas. According to her, the two teachers helped the students to move from using everyday words such as “per” as in “cost per, dollars per, miles per” (p. 102) for rate to more mathematical appropriate words such as slope, gradient and rise/run.

The teachers can pick words and phrases such as those adopted by the students who participated in this research and initiate discussions involving them. They can then let the students move back and forth comparing the words in everyday language and scientific language and their meanings with regard to the target ideas for purposes of familiarizing and gaining proficiency in the use of scientific language to understand and explain ideas in science. In addition, the exercise of moving back and forth could serve to help the students view the idea(s) from two perspectives which could enhance understanding. Furthermore, switching back and forth between everyday language and scientific language may help in modeling the process of developing scientific language by scientists. This modeling, if explained to the students, could help them in appreciating the steps and processes involved in the development of the language of science. As a consequence, it could help ease some of the anxieties associated with learning scientific language given the technical aspects associated with it (Chamot & O'Malley, 1994; Gee, 2005; Rollnick, 2000; Shaw et al., 2010). Suggestions have been made to the effect that scientists begin with everyday language as they seek to understand ideas in science (Sutton, 1998). Sutton argued that the language of science evolves from simple, personal and everyday talk to the more formal language of science that is impersonal and objective in journals and textbooks as scientists engage with their work and share their findings with peers. To illustrate
this kind of language, Sutton describes Faraday’s communication to his friend, Abbot, with regard to Humphry Davy’s views on chlorine gas:

Was the green gas truly a simple elementary substance as Davy had maintained? If so, then the more well-known ‘steamy’ gas from salt which people called ‘smoking spirit of salt’ or ‘muriatic acid gas’ might be renamed ‘hydrogen chloride’ and recognized as a compound of two things only. (p. 27)

Sutton argued that this kind of communication had a personal voice and touch to it, something that is often missing in the language of science in textbooks and science classrooms. Additionally, there is hardly any scientific language in this communication apart from the suggestion of giving the gas in question a scientific name – hydrogen chloride – and referring to it as a compound (also scientific terminology meaning a substance that contains two or more elements chemically combined). Faraday’s argument is replete with everyday language such as “steamy gas,” “smoking spirits of salt” “muriatic acid” and “two things.” Levere (2001) also described the kind of everyday language used by different scientists as they conducted their investigations that contributed to the growth of chemistry as a discipline in science. For example, Levere observed that the word gas was coined from a Greek word chaos: “The particles of gas or of a gas were in chaos, and gas could be a wild spirit because of its habit of escaping from chemical reactions” (p. 51). This, like the case of the communication between Faraday and Abbot described above, shows that the development of scientific language begins from not only everyday language but also everyday thinking and argument (in a scientific sense). Given that scientists who are specialists can begin by talking about ideas involving their work using simple, personal and everyday language, it should happen even more with students learning science and more so for SLSL2.
Other than everyday language, the students who participated in this research had a host of experiences with the phenomena and activities investigated. In addition, they relied on everyday observations in explaining some of the ideas involved. For example, Matini, Imali, Kayali and Aliviza focused on visual but irrelevant details (e.g., many versus few, and heat versus no heat) about droplets on the *sufuria* cover in video #5 of covered water in a *sufuria* over fire and those on the grass in picture #3 of dew on grass. With regard to experiences with phenomena, Kayali talked of how to tell whether or not a battery had voltage by pressing it. And both Kayali and Imali collaborated in giving details of how batteries’ voltage can be increased if determined to be low by placing them on corrugated iron rooftops or near fire to name a few examples. Just like everyday language, everyday observations and, in particular experiences with phenomena, can be used to leverage students’ understanding in science. They can form the starting points for discussions that can lead to further understanding about the phenomena in question. For example, using everyday observations provided by students for given phenomena, a teacher could initiate a discussion in which the students are asked to examine each observation in terms of how it helps in the understanding of the phenomena. That way, the students may realize that there is more to the occurrence of phenomena than what is observable to the eye and hopefully lead them into asking not only the what but also the how question as was asked by a student called Joanne in a study conducted by Ballenger (1997). As mentioned in Chapter Four, the observed features or characteristics of a phenomenon need to be connected to the science behind them, which in most cases is not observable for effective understanding. For example, while water droplets (however many) may be observed on the *sufuria* cover or grass in the morning, the science behind their formation is unobservable. Therefore, the teacher’s role in helping students make connections that lead to meaningful understanding of the science behind the
occurrence of phenomena cannot be overemphasized (Eberbach & Crowley, 2009; Ford, 2005). Furthermore, learning science is participating in a new culture and involves crossing the border from everyday culture to the culture of the science classroom (Aikenhead & Jegede, 1999; Cobern, 1996; Lemke, 2001). In addition, Purcell-Gates (1995) argued that participation in a new culture requires explicit teaching about the new culture. She observed:

Many if not most, cultural practices are learned through participating within a culture. For those new to a culture, though, the implicit must be made explicit to the degree to which the new participant can appropriately interpret behaviors and ways of seeing that are unknown to him or her… it is unfair and unethical to withhold insider information until children or adults “figure it out for themselves,” as if they were insiders all along. (p. 98)

Thus, students and, particularly SLSL2 need be explicitly taught how to make observations that lead to meaningful understanding about scientific phenomena.

As is the case with everyday observations, the experiences the students have with phenomena outside-the-classroom can be used as starting points for learning about science content involving the same phenomena in the classroom. Using the example of pressing a battery to determine its voltage status, a discussion can be initiated in which students talk about the effectiveness and or limitations of such a method. Through such a discussion, the students could come to an understanding for the need of other ways of determining the voltage status of a battery (e.g., the use of a voltmeter), which the teacher can then introduce. It is also possible to incorporate the experience of pressing batteries to determine their voltage in teaching the idea of voltage as a hands-on activity. For example, students could be give batteries of varying voltage and asked to arrange them in order of lowest to highest voltage by pressing them. The students
can then be asked to state the strengths and limitations of such a method, at which point, the teacher may then introduce the voltmeter as a more accurate method. More importantly, such teaching experiences are likely to help the students realize that it is not that their method is wrong. Rather, there may be limitations of adopting such a method and in a way may help them experience what Cobern and Aikenhead (1998) refer to “autonomous acculturation,” which they define as “the borrowing or adaptation of attractive content or aspects of another culture and incorporating them or assimilating them into those of one’s indigenous or everyday culture” (p. 42) into the culture of the science classroom. At the same time, it would help students build new ideas on their existing knowledge and ideas from outside-the-classroom without necessarily replacing them (Heath, 1983).

**Cultural knowledge on thunder and lightning and science learning.** The findings of this research show that the students talked of lightning as being in the form of a red rooster that can attack people, especially if they made noise during a thunderstorm. These findings like those of Pauka et al. (2005), reflect talking about lightning that is different from that in science. The participants (village elders and students) in Pauka et al.’s study had explanations for the occurrence of natural phenomena such as erosion, thunder and lightning and rainbows, which included spirits, spells, and magic. The idea of a red rooster as the form and nature of lightning is an idea that is firmly rooted in the culture of the Bunyore and Maragoli people. As mentioned in Chapter Five, I had heard about it together with some of the dos and don’ts during a thunderstorm (e.g., avoiding red clothing during a thunderstorm) while growing up and yet more than 40 years later, the same ideas were still being talked about by the younger generation. It would thus be accurate to designate the idea of a red rooster as cultural knowledge about thunder and lightning from the perspective of the Bunyore and Maragoli people.
However, it is important to point out that this knowledge may be regarded as cultural knowledge to the extent that it has been passed on from generation to generation for years, but not necessarily because that is the way the general population of the people in these two communities understand the phenomenon of thunder and lightning. This is not to say that there may be people, including students, who may hold onto this knowledge for their understanding of the phenomenon of thunder and lightning as was the case with two of the students (i.e., Imali and Kayali) who participated in this research. For example, Muhonja dismissed the red rooster and red clothing as mere “beliefs” and even went ahead and narrated how she proved it by going to a shop with a red umbrella in which case she was not struck by lightning. However, Imali and Kayali’s speculation for her failed experiment indicates their strong adherence to this cultural knowledge. This then brings me to the question of how such knowledge can be integrated with school science in order to leverage students’ understanding of the science behind the phenomenon of thunder and lightning, particularly for those who may have a strong adherence to the knowledge. This is a crucial question because it must be accompanied by concerns for how the integration can be done such that the students experience smooth transition into the culture of science or “autonomous acculturation” (Cobern & Aikenhead, 1998) and therefore minimize on students’ “walling off” or “compartamentalizing” scientific knowledge for purposes such as examinations (Cobern, 1996). It is an important question because of the necessity to iron out some of the inaccurate understandings students may have about ideas inherent in the phenomena arising from their cultural understanding. An example of an inaccurate idea that arose through talking about thunder and lightning, as described in Chapter Five was the idea that it is light that harms a person when struck by lightning as stated by Yohana. This idea may be rooted in the fact that lightning is accompanied by both light and sound, and light is always seen before sound is
heard. Actually, light and sound are both after-effects of a lightning bolt and because light travels faster than sound, it is often seen before sound is heard.

I believe that the same idea of moving back and forth applicable in helping students gain access to the language of science starting with everyday language described earlier in this chapter would also apply in helping students particularly those who may have a strong adherence to cultural knowledge with regard to given phenomenon experience a smooth border crossing (Aikenhead & Jegede, 1999) into talking about scientific phenomena in scientific ways. Aikenhead (2001) illustrates how this kind of switching back and forth, especially with regard to two knowledge forms can be achieved through the idea of “rekindling traditions” project. In this project, Aikenhead collaborated with a group of teachers and elders from the Aboriginal community to develop unit plans that incorporated both scientific knowledge and Aboriginal knowledge. He explained that the inclusion of the Aboriginal elders in the project was important because they helped in determining what knowledge was important for teaching. According to Aikenhead, one of the key elements of the project was the presence of themes significant to the community, including respect for the Aboriginal knowledge.

The actual teaching of the units began with experts from the community coming to class to “talk about their work and to connect students with the local culture” (p. 346). This was then followed by a teacher providing an overview of the ideas connecting the Aboriginal knowledge to the scientific knowledge. Aikenhead (2001) also explained that in teaching the units, the teacher used two blackboards in class, one for Western science and the other for Aboriginal knowledge. Thus, switching blackboards signaled to the students the context in which they were supposed to operate and therefore the “students consciously switch language conventions and
conceptualisations” (p. 347). Aikenhead argued that this kind of cross-cultural teaching enables students to gain access to Western science without losing their cultural identity.

However, there needs to be a point of reference for enacting this kind of teaching. For purposes of school learning, the easiest and most effective point of reference is the syllabus. This is because the syllabus is the document that guides not only what is taught and learned but also how it is taught and learned. The syllabus needs to be explicit in not only providing examples of experiences (i.e., phenomena and activities) from outside-the-classroom that involve ideas learned in the classroom but also recognizing that there may be cultural understanding of ideas involved in those experiences. For example, the idea of providing thunder and lightning as an illustration of a phenomenon involving the idea of static electricity and recognizing that there could be cultural understanding about it is likely to condition the teachers to seek the students’ understanding from outside-the-classroom related to the phenomena and perhaps make attempts of incorporating it in their teaching.

Cultural talk about thunder and lightning as revealed through this research could easily be used as a launch pad for a stimulating debate with and among students that can leverage the students’ understanding of ideas on not only static electricity but also the phenomenon of thunder and lightning itself. For example, at some point in the teaching, the students could be placed in a situation where they are made to compare and contrast the two forms of knowledge (i.e., cultural and scientific) in terms of their purposes, how they are constructed and passed on to the other people. Through such an activity, the students may come to an understanding of not only the processes involved in establishing a given system of knowledge, but also the values that lead to people developing confidence in it. They may also come to an understanding that the two forms of knowledge aim ultimately at keeping people safe from the effects of thunderstorms.
Finally, through such an activity, students such as Muhonja may learn the need for safety for self and others while conducting an investigation. Muhonja is the student I talked about in Chapter Five who dismissed the ideas of a red rooster as a form and nature of lightning and avoidance of red clothing during a thunderstorm as “beliefs.” She narrated how she came to prove the ideas as being “beliefs” through an experiment – going to the shop with a red umbrella, which did not result into her being struck by lightning. Muhonja may not have known that she risked her life by doing what she did because, while the color red may not have an effect on someone being struck by lightning the umbrella would especially if the handle was metallic.

**Participation in discussions involving science ideas.** The findings of this research suggest that possibilities exist for students who may seem uninterested in participating in discussions related to ideas in science to participate. This is drawn from immense participation in a discussion on thunder and lightning by Imali who originally appeared withdrawn and uninterested in making contributions during other sessions of the focus group discussions. This finding is consistent with that in a study conducted by Ballenger (1997). In addition to the finding that in using Haitian Creole to talk about a scientific task – mold growth – the students brought their personal experiences of how to clean the bathrooms and what materials to use, Ballenger also found that the students asked high-level questions that could be investigated scientifically. Furthermore, she found that one student, Caroline, who had hardly talked during previous discussions joined in the discussion using her knowledge of domestic routines. Ballenger observed of Caroline: “She has rarely spoken in science discussion before this point, like Manuellee and Joanne, her knowledge of domestic routine gives her a point of entry into the discussion” (p. 9). Thus, Caroline’s familiarity and perhaps involvement with domestic routines provided her an entry into the discussion.
In this research, Imali’s participation was more pronounced during the discussion on thunder and lightning and also to a small extent during the discussions on evaporation and condensation outside-the-classroom context and that of batteries and the flashlight. During the discussion on thunder and lightning, as noted in Chapter Five, Imali made contributions that included the dos and don’ts during a thunderstorm. She also questioned and challenged her peers on their ideas, proposed first aid to be given to a victim of a lightning strike and even speculated as to why Muhonja’s experiment (i.e., testing whether or not she would be struck by lightning by going outdoor in rain with a red umbrella) did not work. During the discussion on evaporation and condensation outside-the-classroom context, Imali described the substance that was being formed as the water boiled in a sufuria over as seen in video #5 heat as hewa (Kiswahili for air). On the other hand, during the discussion on the flashlight and batteries, Imali talked of her experience of having observed how the batteries’ voltage can be increased if determined to be low by placing them on iron rooftops or near fire.

While it may have been possible that familiarity with the ideas being discussed provided Imali with the “entry points into the discussions” (Ballenger, 1997). It is also possible that the language used during the discussion involving the episodes described above gave Imali the confidence to engage in the discussions. The discussions in which these episodes occurred were representative of the outside-the-classroom contexts and as mentioned in previous chapters (i.e., Chapter Three and Five) the main language of discussion for the outside-the-classroom contexts was Kiswahili. As mentioned earlier, Kiswahili may not be considered the students’ first language in Kenya. However, its status as a national language has enabled the general population of people in Kenya to develop proficiency in most of the aspects of the language that include writing, speaking and reading. Thus, in a sense Kiswahili could easily hold the same
status as the first language for a majority of the population of people in Kenya and therefore its use during the discussions outside-the-classroom contexts may have given Imali the confidence to give her contributions during the discussions. I note this because Imali hardly spoke during discussions for the inside-the-classroom context. During these discussions, English was the main language of discussion.

The idea of the language of instruction being different from the students’ first language and therefore a hindrance to access to content in school learning has been documented (Broke-Utne, 2007; Duran et al., 1998; Evans & Cleghorn, 2010; Luykx et al., 2008). The common theme in these studies is that the students failed to learn science in meaningful ways. However, language should be viewed and used as a tool for enhancing human communication rather than a hindrance (Shatz & Wilkinson, 2010; Vygotsky, 1978). Thus, students such as Imali can be helped to gain meaningfully in learning content in school subjects, including science. This idea was illustrated by Broke-Utne (2010). It is one of the studies I have reviewed in Chapter Two for literature review. The study, which was conducted in Tanzania, involved two groups of students learning subjects in the school curriculum specifically, biology and geography. One group was taught in English and the other one taught the same concepts in Kiswahili, the students’ first language. Broke-Utne found that the there was more meaningful learning in the classes where the students learned content in Kiswahili compared to that where students were taught in English. Broke-Utne argued that there was more meaningful learning in the classes where students were taught in Kiswahili because the students brought to class their experiences with phenomena from outside-the-classroom on which the teachers built new ideas. In addition, she found that in the classes where the students were taught in Kiswahili, the students were livelier as they contributed their ideas during the teaching learning process.
Thus, in drawing on the students’ first language, students can be supported in gaining entry into discussions that they would have otherwise been locked out. Kenya has a policy on the language of instruction enacted in the mid-1970s. The policy set English as the language of instruction starting from Standard Four (fourth grade) for all subjects in the school curriculum except Kiswahili. This policy may limit the teachers’ ability to draw on the students’ first language to leverage their learning. However, I believe that the teachers can draw on the students’ first language without necessarily violating the language of instruction policy. This is especially the case when both the teacher and the students can speak the same language, as is the case in Kenya with Kiswahili.

The idea of moving back and forth as described earlier could also apply here. In this case, a teacher could allow students to move back and forth between the language of instruction and the students’ first language during discussions on ideas in science, with particular attention directed at the students who may not be making contributions in the discussions. The teacher can encourage them to make their contributions in the language they feel comfortable. After such students make their contribution the other students, who may be more proficient in the language of instruction, with the help of the teacher could translate the contributions in English for purposes of helping the less proficient students to master the language of instruction, which may become a valuable tool during examinations. Through such an action, the students who may be having difficulties with the language of instruction are likely to bring their experiences with phenomena from outside the classroom into discussions on ideas involving those ideas.

Implications

Through this research a number of findings emerged as noted earlier. I discuss the implications of these findings on teaching and learning science in an endeavor to answer the
fourth and final research question about implications for how students talked about scientific phenomena both outside- and inside-the-classroom contexts on science learning. The first three research questions about how students talked about physical science phenomena both outside- and inside-the-classroom contexts and the similarities or differences between the talk in both contexts and in science classrooms were addressed in Chapter Four and Five of this dissertation. I discuss the implications of the findings under the headings teaching that draws on students’ everyday ways of making sense of the world and establishing entry points for students in discussions on science.

Teaching that draws on students’ everyday ways of making sense of the world. The students who participated in this research are representative of more than 60% of all of the students at the secondary school level in Kenya based on the data in Tables 1, 2 and 3 (i.e., students who attend public, day and mixed gender secondary schools). Even though the students represented by this percentage may not all be attending schools in rural areas and therefore may not share the same language with peers, a sizeable percentage of them do, given that 78% of the general population of people in Kenya live in rural areas as per the data from UNESCO (UNESCO, n.d.). For those who attend school in rural areas, their schools may be located in their communities and therefore may share and speak the language of the community in which the school is located. Outside the classroom, they may talk about scientific phenomena in ways that are different from those emphasized inside the classroom. Thus, this is a population of students who should not be ignored not only because they are many but because they need to learn science and other subjects in the school curriculum in meaningful ways.

The findings of this research have shown that the students who participated adopted everyday ways of talking (i.e., the use of everyday language and reliance on everyday
observations) in describing and explaining ideas inherent in the phenomena investigated in this research. In addition, cultural knowledge about thunder and lightning emerged through this research. Science teaching needs to be done in ways that enable the students to cross the cultural border between their everyday ways of talking and that of science and not only view but also understand and talk about ideas in science in scientific ways – those that draw on the language of science. I envision such teaching as one that begins from the spot where the students are (i.e., the everyday spot). Students’ everyday ways of making sense that include language and experiences are rich resources and starting points in instruction that can leverage students to higher levels of learning of ideas in science. If science is taught in ways that do not pay attention to students’ ways of making sense of the world, the students are likely to “wall off” or “compartmentalize” the science ideas taught and only retrieve them during times such as examination (Cobern, 1996).

Science teaching that starts from students’ ways of making sense is likely to be easier if teachers are not only aware of the everyday ways of making sense of the world students are likely to bring to the classroom, but also have the abilities to leverage students’ learning by drawing on them. It is also likely to be easier if curricula tools such as the syllabus provide a basis for enacting such teaching. As mentioned Chapter Four, the syllabus is explicit on content to be taught and objectives for teaching such content. It also recognizes the need to link some of the science ideas to their industrial applications. However, clearly missing in the syllabus were examples of phenomena and activities involving ideas investigated in this research that students are likely to encounter in their everyday lives. The syllabus needs to be explicit in providing examples of phenomena and activities representing the ideas in science content that students are likely to experience in their everyday lives and acknowledge that there could be cultural understandings and talk that may accompany ideas in such examples and phenomena. This way,
teachers are likely to be conditioned in seeking not only students’ experiences with phenomena and the talk surrounding the phenomena, but also making attempts of connecting those experiences and talk with their teaching.

Even after curricula materials (i.e., the syllabus) recognize that students may have an understanding about science ideas taught in the classroom arising from contexts other than the classroom and are explicit on examples of phenomena and possible students’ experiences with them, teachers need to be able to enact teaching that draws on students’ ways of understanding and talking. This research involved only two teachers who I did not observe teaching but only interviewed. Therefore, it would be inappropriate to draw generalized statements about the status of teachers’ awareness of students’ ideas arising from contexts other than the classroom and their ability to enact teaching that draws on those ideas based only on interview transcripts of two teachers. However, differences were evident between the two teachers in terms of not only their abilities to provide examples of students’ experiences with phenomena involving ideas investigated but also reasons for using them in teaching.

For example, Chris provided numerous examples of experiences involving ideas in physics he taught but he used those examples to change the attitudes of the students. He also stated that he was aware that students had an understanding about thunder and lightning that was different from the one emphasized in the science classroom. He further stated that he tried to help the students to reconcile the alternative understanding about thunder and lightning and science but emphasized more on science because of examination. On the other hand, Evelyn was limited in providing examples of students’ experiences with phenomena and activities investigated in this research. She seemed not to be aware of students’ understandings and talk from outside the classroom about ideas inherent in the same phenomena and activities.
Given these differences in Chris and Evelyn’s descriptions of their own teaching of ideas investigated in this research, it is possible that such differences exist among the general population of teachers in Kenya. Thus, it becomes necessary to harmonize teachers’ thinking with regard to not only their awareness of students’ ideas and talk from outside the classroom but also the need to enact teaching that draws on such ideas. Harmonization of this kind may be achieved through professional development programs for teachers who are already in the teaching service and teacher education programs for pre-service teachers preparing to become teachers.

**Establishing entry points for students in discussions on science.** The findings of this research, like those of Ballenger (1997), show that possibilities exist for students who may seem uninterested in participating in discussions involving science ideas to participate. This is based on the finding that one student, Imali, rose above her peers and made immense contributions during the discussions on thunder and lightning, and to a small extent during the discussion on electric current (in particular batteries and their voltage) and evaporation and condensation, only for outside-the-classroom context. Both the discussions on thunder and lightning and batteries and their voltage were representative of discussions for an outside-the-classroom context. As noted earlier, the discussions for outside-the-classroom were conducted in Kiswahili. Imali’s familiarity with not only the ideas being talked about but also how they were being talked about could have provided her with “entry points” into the discussions (Ballenger, 1997). Likewise, Kiswahili, which is the language that was being used during these discussions, may have given Imali the confidence to engage in the discussions. These findings therefore seem to point to a need to establish entry points for students who may not be participating in discussions involving science ideas to enable them participate. The entry points may involve
structuring the discussions in such a way that the students are able to draw on their experiences with phenomena from outside the classroom and how they talk about them in order to engage in the discussions. Structuring the discussions might involve asking the students to use a language with which they are comfortable.

While the idea of asking the students to use the language they are most comfortable with might look like a contravention of the language of instruction policy in the case of Kenya, I believe that such an action could bolster the language of instruction skills in the students, especially for those whose proficiency in the language of instruction is low. This is because, with the help of a teacher, students who are more proficient in the language of instruction could revoice ideas spoken in another language using the language of instruction to benefit the students who are less proficient in the language. This way, the non-participating students will not only have a chance to participate in the discussions but also learn how to say the same ideas in the language of instruction.

The teaching approach of asking the students to draw on the language they are most comfortable with is likely to work well in a country such as Kenya where possibilities exist for teachers to share the same community language with students, as was the case with the two teachers who participated in this research. Even if teachers did not share the same community language with the students, the idea of Kiswahili being a language that is spoken by all communities provides both teachers and students an additional medium of communication that can be used to help students talk about their ideas during discussions involving scientific ideas without having the teacher to seek help on understanding the students.
Conclusion

Through this research, I sought to determine how secondary school students talk about ideas inherent in physical science phenomena they encounter in their everyday lives as well as learn about in their science classroom. The research involved seven Form Two students, three boys and four girls, from one public, mixed gender day secondary school in Vihiga constituency, Vihiga County of Western region in Kenya. The school which has been in existence since the mid-1990s, had a student population of about 200 students comprising. I collected data from the students through focus group discussion sessions as they engaged in talking about ideas in selected physical science phenomena both outside- and inside-the-classroom contexts. The ideas included dissolving – experienced in everyday activities such as adding salt or sugar to food, evaporation and condensation – experienced through phenomena and activities such as steam forming on roads or rocks following rain on hot day, cooking and dew on grass in the morning, static electricity – experienced through phenomena such as thunder and lightning on a large scale and static cling on a small scale, and current electricity – experienced through activities such as phone battery charging and handling of batteries as used in radios and flashlights.

I conducted a total of six discussion sessions lasting on average 41 minutes per session. Prior to conducting the sessions, I cued the students to experience the phenomena and activities for the outside-the-classroom context through watching short videos (one to two minutes long) and pictures on my laptop placed at a strategic point for all to have a clear view. As for the inside-the-classroom context, the discussions were preceded by demonstrations of hands-on activities on ideas inherent in the phenomena and activities investigated using apparatus and materials as would have been done inside the science classroom conducted by me. To supplement the data from the focus groups discussions I interviewed two teachers, one for
chemistry and one for physics, through one-to-one interviews to gain insights on how they taught ideas involving the phenomena investigated in this research. In addition, I examined the syllabus for objectives and content, and level of treatment of content as well as the students’ responses to questions on teacher-made assessments involving ideas investigated in this research.

A number of findings emerged through this research. First, the students adopted everyday ways (i.e., everyday language and everyday observations) in describing and explaining the ideas inherent in the phenomena and activities investigated in this research. In doing so, their experiences with the phenomena investigated seemed to influence their talk and specifically the choice of words used to describe and explain the ideas. Second, cultural talk about thunder and lightning emerged through this research that is different from that emphasized in science and science classrooms. Lastly, the findings of this research just like those of Ballenger (1997) have shown that possibilities exist for students who may initially seem uninterested in participating in discussions involving science ideas to participate.

The conclusion based on the findings of this research is that the students who participated in this research were yet to cross the cultural border between their everyday culture and that of the science classroom and thus view and talk about ideas involved in the phenomena and activities investigated in scientific ways – those that utilized scientific terminologies and language. The students were in Form Two, the second of the four years at secondary school level while the science ideas investigated are part of the Form One chemistry and physics content. It was therefore expected that the students had learned about the ideas investigated in this research in their science classroom. The students’ responses to questions on teacher-made assessment corroborates the assertion that the students were yet to cross the cultural border into the culture of the science classroom because they demonstrated a weak understanding of the ideas assessed.
even on questions at the knowledge level. In addition, everyday language (i.e., some of the words adopted during focus group discussion outside-the-classroom context) also filtered into some of their responses. Thus, the students effectively fit in group X as shown in figure 1. This is a group of students who, despite learning science, they still operate in their everyday culture.

The findings of this research are important because they have shown that SLSL2 talk about ideas inherent in scientific phenomena in outside the classroom in ways that may be different from those emphasized in the science classroom. As such, if science learning for these students is to be meaningful, attention needs to be paid to their cultural and linguistic backgrounds. This may help the students make connections between their experiences with phenomena and related talk about ideas inherent in the phenomena in outside the classroom contexts and those in the science classroom.

**Recommendations and Further Research**

The findings of this research are important because they show the need to pay attention to how students talk about scientific phenomena in outside-the-classroom contexts to leverage their learning. However, given that this research focused on students from only one of the many communities in Kenya, it would be important to determine how students from other communities in Kenya talk about ideas inherent in the phenomena investigated in this research. Information arising from such research would provide teachers with ideas on what to draw on in leveraging students’ science learning in those communities.

It is likely to be easier for teachers to draw on their students’ ways of making sense of the world if they have the basis for such actions. Given that the syllabus is the document that guides teachers on what to teach in schools, it is important that it identifies examples of experiences and phenomena in everyday life involving ideas learned in science as well as recognize that there
could be cultural understanding accompanying such phenomena. Besides the syllabus being explicit on examples and experiences in everyday life related to ideas in science, research needs to be conducted to determine the extent of teachers’ awareness of how students talk about scientific phenomena arising from their everyday interactions outside the classroom. Based on the findings from such investigations, appropriate action can be taken (i.e., organizing PD programs for teachers and or sensitizing pre-service teachers on the need to pay attention to how students talk about scientific phenomena in contexts outside the classroom).

What Next?

The writing of this dissertation concludes a research project whose findings I believe have the potential to influence the teaching and learning of science by students learning science in a language other than their first language. The findings of this research have shown that students drew on their everyday ways of making sense of the world (i.e., everyday language and everyday observations) in describing and explaining ideas inherent in the phenomena investigated both outside- and inside-the-classroom contexts. In other words, the students were unable to view and talk about the ideas inherent in the phenomena investigated especially in the inside-the classroom context in scientific ways – those that drew on scientific language. This was likely due to teaching that did not help the students to make connections between how they talk about phenomena outside the classroom and how the same phenomena are talked about in the classroom.

I have made some suggestions on how science teaching needs to be done so that it draws on students’ ways of making sense of the world to leverage them to higher levels of effective learning in science, particularly for students in contexts where they may encounter English, the language of instruction only in the classroom. Most of what I have written in this dissertation to
that effect drew from work by other scholars (e.g., Aikenhead, 2001; Ballenger, 1997; Brock-Utne, 2007; Herbel-Eisenmann, 2002; Warren et al., 2001). I am not sure how those suggestions would play out, particularly in a context such as Kenya where there is a policy on the language of instruction. However, given my previous work engagement in Kenya prior to coming to graduate school in the U.S. as an INSET provider involving mathematics and science teachers, I might begin by sharing the findings of this research with them as a strategy to get them to start seeing the need to draw on students’ everyday ways of making sense of the world. If and when they see the need, I would like to move forward by working with a willing group of teachers through planning and enactment of lessons that draw on students’ talk about scientific phenomena arising from contexts outside the classroom. If indeed it works that teachers can draw on students’ everyday ways of making sense of the world and that such ways lead to meaningful science learning then amendments can be recommended that influence not only policy on language of instruction (e.g., addition of riders to the policy that give teachers authority to move back and forth between the language of instruction and Kiswahili) but also how curricula materials are drawn.
References


NAME OF AUTHOR: Grace N. Ora

PLACE OF BIRTH: Vihiga County, Kenya

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

- Syracuse University, Syracuse, NY
- Kenyatta University, Nairobi, Kenya

DEGREES AWARDED:

- Ph.D., Science Education, Syracuse University, Syracuse, NY
- M. ED., Science Education, Kenyatta University, Nairobi, Kenya
- B. ED., Education (Science), Kenyatta University, Nairobi, Kenya

AWARDS AND HONORS:

- Graduate Teaching Assistantship, Syracuse University
- Syracuse University's School of Education Research and Creative Proposals' Grant for 2012-2013 ($700), one of the ten winners

PROFESSIONAL EXPERIENCE:

- Graduate Teaching Assistant, Department of Science Teaching, Syracuse University, NY
- Graduate Research Assistant, Department of Science Teaching, Syracuse University, NY
- Examiner, Kenya National Examinations Council (KNEC), Nairobi, Kenya
- Test Developer, Kenya National Examinations Council (KNEC), Nairobi, Kenya
- Curriculum development of secondary school general science curriculum, Kenya Institute of Curriculum Development (KICD), Nairobi, Kenya
Appendices

Appendix A: Map of Kenya showing the eight regions

Key
1. Central
2. Coast
3. Eastern
4. Nairobi
5. Northeastern
6. Nyanza
7. Rift Valley
8. Western

Appendix B: Semi-structured teachers’ interview protocol

Teacher’s background information
1. How long have you been teaching? At this school?
3. What subjects were you trained to teach?
4. What subjects are you teaching currently?
5. How long have you taught Form one chemistry/physics?

Teaching ideas in physics and chemistry related to:
   o Static electricity
   o Electric current
   o Dissolving
   o Evaporation and condensation
1. How would you describe your teaching of ideas related to static electricity and electric current in physics? Dissolving, evaporation and condensation in chemistry? Any specific hands on activities you use? Why? Any specific examples you give when teaching these ideas? Why?
2. What concerns do you have as you prepare to teach these ideas? When teaching? When assessing students on these ideas? How do you go about addressing the concerns?
3. How would you describe the students’ learning of these ideas? Do they enjoy? Do they seem lost? Reasons behind their behavior? What ideas if any do you think students come to class holding about these topics? How do you help students integrate their ideas with those you teach in these topics?
4. Describe the kinds of help you may have received that have enhanced your teaching of these ideas? From whom? How often do you get such help? How useful is such help?
5. Anything else you would like to talk about?
Appendix C: Pictures used during focus group discussions for the outside-the-classroom context

Picture #1 - practice
Source: http://www.google.com/imgres?imgurl

Picture #2 - practice

Picture #3
Source: http://www.google.com/#hl=en&tbo=d&sclient=psy-ab&q=images+of+dew+on+grass&oq

Picture #4
Source: http://courtney-watkins.com/2012/06/29/static-cling-solutions/
Appendix D: Some pictures from Vihiga constituency

A rocky hill

Earth road

A footpath joining two homesteads

Rocks on a piece of land
Appendix E: Students’ “round-table conversations” on the idea of dissolving

Dissolving Parts I & II

1. She started for the salt to mix well in the vegetables. If she doesn’t stir the salt will not be in some parts of the vegetables.

2. If the salt added is too much...

3. She will add a little water.

4. Now if she adds water, it mixes with the salt, it removes the salt. If the salt was too much it will remove it so that it remains a little.

5. She can add water, then draw the water from the vegetables and then return the vegetables on fire. She can then boil the water which will get finished and the salt will remain in the sufuria.

6. She put the salt then picked the spoon and started mixing so that the vegetables could mix well with the salt together with the tomatoes and onions.

7. It has dissolved in the same breath.

8. The salt has been mixed up with the water.

9. Now when she makes the salt with the vegetables she cannot see it because it usually melts.

10. That water from the rain mixes with the fertilizer and then it is transported from the soil through the roots up to the plant parts so that the plant can give better yields.

11. When water gets finished in the sufuria it goes...

The language of “mixing” is still persistent even when talking of real life experiences with dissolving.

Now if you take a fertilizer and put it in a maize plantation, it will just stay there, it will not melt. It will just stay there and it will not mix with the soil, and therefore will not help the maize to grow.

Petronila will add water.

Dissolving means...

By dissolving the water removes a little salt or reduces salt or removes the strength of salt.

It is to get rid of the strength of the salt if it is too salty.

A little water to remove a little salt.

She will add a little water.

This means that the vegetables will not hold together meaning they will not be the same...she started to stir so that all parts of the vegetables would have enough salt.

If she wants the salt to mix with the vegetables at the bottom

When you added it, you shook it and mixed it with the water. Now if you taste that water it will have salt.

The power of senses in knowing.

Now if a he has put a lot of salt, the salt will eat a little of the vegetables to be sure that the salt is enough or just enough then she adds more.

She put the salt then picked the spoon and started mixing so that the vegetables could mix well with the salt together with the tomatoes and onions.

She started to stir so that all parts of the vegetables would have enough salt.

Stirring ensures that the contents of the sufuria “mix well.”

You will know it is there because you added it there.

The salt is mixed up with the water

It has dissolved.

It will mix with the water then the salt will not be visible.

It will be visible inside the water.

Appendix E: Students’ “round-table conversations” on the idea of dissolving

Now when she mixes the salt with the vegetables she cannot see it because it usually melts.

By dissolving the water removes a little salt or reduces salt or removes the strength of salt.

It is to get rid of the strength of the salt if it is too salty.

A little water to remove a little salt.

She will add a little water.

This means that the vegetables will not hold together meaning they will not be the same...she started to stir so that all parts of the vegetables would have enough salt.

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The power of senses in knowing.

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It has dissolved.

It will mix with the water then the salt will not be visible.

It will be visible inside the water.
Appendix F: The looping idea for students’ conversations about thunder and lightning

1. To show that the rain was about to start raining there was thunderstorm and lighting. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

2. Thunderstorm start with cloud cover

3. If you are in the house you are not supposed to be at the corner of the house or near the wall. While inside the house avoid noise especially if the rain is a lot.

4. Lightning is unique

5. Lightning just passes through that. It "beats" trees and that is a tree.

6. It is because before lightning appears charges must be touching each other that is why it lights on and off. Lightning "beat", "find", "burn", or "pass" with people or things.

7. Lightning can pass through and "find" you. What will it do?

8. So do you mean to say that if you have shoes on and it is raining that way it will not "hit" you? What about if it has "hit" you and you are dead?

9. Another one is that you are not supposed to walk outside because the thunderstorm and lighting are rattling. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

10. People are "hit" by... The thing that harms a person when lightning appears is the light. That light is more powerful than sound because sound comes last... but with light, the moment it lights you up, it has already passed and it has already harmed you.

11. It is electricity that passes through a wet one but this is lightning it will just "find" you. The one used is normally dry, it is not wet.

12. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

13. It is the wall

14. Be careful what will it do?

15. Charges form by... When clouds come from one end when they have a positive charge and others come from another end when they have a negative charge and the two meet they make lightening which.....light comes faster that sound.

16. It depends on the kind of rain. If it is one with a "lot" of lightning and thunderstorms are rattling, that one you can not come out of the house. But if it is one with little whatever, lightning cannot "beat" you.

17. When lightning appears it is looking for whatever to pass through as it goes to the ground. Now if you don't have shoes on, our bodies have a lot of water and water is a good conductor of electricity. Now that whatever can pass through you to go to the ground but if you have shoes on, they do not allow electricity to pass through them. Now it will just reach the shoes and it gets stuck.

18. It is one with "a lot" of lightning and thunderstorms are rattling. That is what made the rain to start raining. So a few minutes following the thunderstorm it started to rain.

19. It is electricity that passes through a wet one but this is lightning it will just "find" you. The one used is normally dry, it is not wet.

20. It can only "beat" you if you are holing onto the metal part but they have put there whatever, it prevents that from traveling. So when you hold it and it has it, it cannot "beat" you.

21. But... Lightning just passes through that. It "beats" trees and that is a tree.

22. I think that the weather started to change before the thunderstorm appeared. And it appeared because of the presence of clouds that is when the weather started showing signs of changing.

23. The thing that harms a person when lightning appears is the light. That light is more powerful than sound because sound comes last... but with light, the moment it lights you up, it has already passed and it has already harmed you.

24. It is the wall

25. It is electricity that passes through a wet one but this is lightning it will just "find" you. The one used is normally dry, it is not wet.

26. It can only "beat" you if you are holing onto the metal part but they have put there whatever, it prevents that from traveling. So when you hold it and it has it, it cannot "beat" you.

27. But... Lightning just passes through that. It "beats" trees and that is a tree.

28. The thing that harms a person when lightning appears is the light. That light is more powerful than sound because sound comes last... but with light, the moment it lights you up, it has already passed and it has already harmed you.

29. It is electricity that passes through a wet one but this is lightning it will just "find" you. The one used is normally dry, it is not wet.

30. It can only "beat" you if you are holing onto the metal part but they have put there whatever, it prevents that from traveling. So when you hold it and it has it, it cannot "beat" you.
Appendix G: Kenya’s coat of arms and KANU’s emblem

Coat of arms
Source: http://arkafrika.com/projects/kenya-coat-arms

KANU’s Emblem,
Source: http://upload.wikimedia.org/wikipedia/en/7/77/Kenya_African_National_Union.gif
Appendix H: Research authorization letter – Kenya

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787, 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

Our Ref: 

NCST/RCD/14/013/257

Grace Nyandiwa Orado
Syracuse University
USA.

RE: RESEARCH AUTHORIZATION

Following your application dated 14th March, 2013 for authority to carry out research on “Investigating ways of understanding and talking about physical science phenomena outside and inside the classroom among secondary school students in Kenya,” I am pleased to inform you that you have been authorized to undertake research in Vihiga District for a period ending 31st August, 2013.

You are advised to report to the District Commissioner and the District Education Officer, Vihiga District before embarking on the research project.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

DR M.K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The District Commissioner
The District Education Officer
Vihiga District.
Appendix I: Research permit – Kenya

Republic of Kenya

Research Clearance Permit

This is to certify that:
Prof./Dr./Mr./Mrs./Miss/Institution
Grace Nyanduiwa Oraro
of (Address) Syracuse University
USA,
has been permitted to conduct research in

Vihiga
Western
District
Province

on the topic: Investigating ways of understanding and talking about physical science phenomena outside and inside the classroom among secondary school students in Kenya.

for a period ending: 31st August, 2013.

conditions

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two (2)/four (4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

Applicant’s Signature

Secretary
National Council for Science & Technology

GPK605563mt10/2011
Appendix J: Research approval, IRB – Syracuse University

SYRACUSE UNIVERSITY
Institutional Review Board
MEMORANDUM

TO: Sharon Dotger
DATE: May 17, 2013
SUBJECT: Expedited Protocol Review - Approval of Human Participants
IRB #: 13-111
TITLE: Investigating Ways of Understanding and Talking About Physical Science Phenomena Outside and Inside the Classroom Among Secondary School Students in Kenya

The above referenced protocol, submitted for expedited review, has been evaluated by the Institutional Review Board (IRB) for the following:
1. the rights and welfare of the individual(s) under investigation;
2. appropriate methods to secure informed consent; and
3. risks and potential benefits of the investigation.

Through the University’s expedited review process, your protocol was determined to be of no more than minimal risk and has been given expedited approval. It is my judgment that your proposal conforms to the University’s human participants research policy and its assurance to the Department of Health and Human Services, available at: http://orip.syr.edu/human-research/human-research-irb.html.

Your protocol is approved for implementation and operation from May 17, 2013 until May 16, 2014. If appropriate, attached is the protocol’s approved informed consent document, date-stamped with the expiration date. This document is to be used in your informed consent process. If you are using written consent, Federal regulations require that each participant indicate their willingness to participate by signing the informed consent document and be provided with a copy of the signed consent form. Regulations also require that you keep a copy of this document for a minimum of three years.

CHANGES TO APPROVED PROTOCOL: Proposed changes to this protocol during the period for which IRB approval has already been given, cannot be initiated without IRB review and approval, except when such changes are essential to eliminate apparent immediate harm to the participants. Changes in approved research initiated without IRB review and approval to eliminate apparent immediate hazards to the participant must be reported to the IRB within five days. Protocol changes are requested on an amendment application available on the IRB web site; please reference your IRB number and attach any documents that are being amended.

CONTINUATION BEYOND APPROVAL PERIOD: To continue this research project beyond May 16, 2014, you must submit a renewal application for review and approval. A renewal reminder will be sent to you approximately 60 days prior to the expiration date. (If the researcher will be traveling out of the country when the protocol is due to be renewed, please renew the protocol before leaving the country.)

UNANTICIPATED PROBLEMS INVOLVING RISKS: You must report any unanticipated problems involving risks to subjects or others within 10 working days of occurrence to the IRB at 315.443.3013 or orip@syr.edu.

Office of Research Integrity and Protections
121 Bowne Hall, Syracuse, New York 13244-1200
(Phone) 315.443.3013 (Fax) 315.443.9889
orip@syr.edu • www.orip.syr.edu

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SYRACUSE UNIVERSITY
Institutional Review Board

STUDY COMPLETION: The completion of a study must be reported to the IRB within 14 days.

Thank you for your cooperation in our shared efforts to assure that the rights and welfare of people participating in research are protected.

Kathleen King, Ph.D.
IRB Chair

Note to Faculty Advisor: This notice is only mailed to faculty. If a student is conducting this study, please forward this information to the student researcher.

DEPT: Science Teaching, 107 Heroy Geology Lab

STUDENT: Grace Orado

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