Research Article

Interpreting Student Views of Learning Experiences in a Contextualized Science Discourse in Kenya

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Abstract: Despite the centrality of the informal manufacturing sector (*Jua Kali*) to the Kenyan society and its richness in scientific phenomena, there is no strong link between activities in the Jua Kali and school science. And, although there has been an ongoing public discourse in Kenya to industrialize, this hope is unlikely without connecting classroom science to the real world of the Jua Kali. In view of this concern, an interpretive case study was framed to investigate Kenyan high school students' views of contextualized science learning in culturally relevant real-world science curriculum. This article reports the analysis of Kenyan students' views of contextualized science learning and school science curriculum and instruction elicited through an interpretive case study approach employing interview methods. The analysis of interview data reveals that the participating students interviewed expressed views that: (1) acknowledged the richness of Jua Kali in scientific phenomena and embedded science; (2) indicated existence of a lack of meaningfulness and relevance in existing science curriculum and instruction model; (3) revealed experience of resonance of group and real life learning strategies modeled in the curriculum unit with their preferred learning modes; and (4) revealed their metacognitive assessment of the traditionally used and the new contextualized science modeled learning strategies. Thus, this article offers insight about the Kenyan students on their journey through the experience of contextualized science learning. © 2013 Wiley Periodicals, Inc. J Res Sci Teach 50: 381–407, 2013
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This article argues that classroom knowledge should have relevance to real-world contexts, and that students' worldviews of science drawn from relevant local contexts will be a significant part of an enabling motive for supporting the locally evolving industries in Kenya and the global community. As the National Research Council (2009) noted in the executive summary of a report on *Learning Science in Informal Environment: People, Places and Pursuits*:

> Everyday experiences can support science learning for virtually all people. Informal learning practices of all cultures can be conducive to learning systematic and reliable knowledge about the natural world. Across the life span, ... individuals learn about the natural world and develop important skills for science learning (p. 2).

Over the last two decades, an informal sector known as "Jua Kali" where small-scale manufacturing and service industries are commonplace in Kenya, has become the largest

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employer of elementary and high school graduates (McLeanand & Kamau, 1999). The name, Jua Kali, is derived from the conditions (scorching sun) under which the artisans who manufacture equipment and provide related services to other small-scale producers operate. McCormick (1998) eloquently describes the Jua Kali as a place alive with activity and sound of hammers on metal; a place where hundreds of artisans and their trainees fabricate metal products including kerosene lamps, chicken brooders, brightly painted boxes, wheelbarrows, charcoal stoves, cooking pots and utensils, and many more, which are sold to wholesalers and direct to consumers (Figure 1). The place is hot and dusty with most of the artisans working without shelter, although a few have roofed sheds.

Embodied in the daily manufacturing processes are a diversity of applied sciences including thermodynamics and chemical transformations and reactions, which students from local schools could investigate (Figure 2). Based on NRC's (2009) report, Jua Kali can be a novel context for learning science. This is because Jua Kali is a common and familiar element of almost every community in Kenya and has become the most direct pathway for securing employment (Cohen, 2004) by high school-graduates compared to finding jobs in the diminishing formal sector (such as the public service).

Interestingly, despite the Jua Kali's centrality in the Kenyan society and the rich application of the applied sciences, and despite the ongoing rhetoric, which has now been entrenched in Kenya's development plans (e.g., The 1997–2010 Republic of Kenya Master Plan on Education and Training, MPET, 1998) that propose to have Kenya industrialized by the year 2020, there is no strong link between activities in the Jua Kali and students' school science (classroom knowledge). Besides, any attempts to link classroom science to the real world (King & Ritchie, 2012) is limited if there is no clear understanding of students' views of learning science in culturally relevant real world, which for Kenyan students is the real world of Jua Kali. Moreover, understanding students' views is important from a pedagogical

Figure 1. Typical Jua Kali site. [Color figure can be seen in the online version of this article, available at http://wileyonlinelibrary.com/journal/tea]

Figure 2. Students engaging with Jua Kali artisan about *Improved Jiko Oven*. [Color figure can be seen in the online version of this article, available at http://wileyonlinelibrary.com/journal/tea]

perspective that considers learners' prior understandings and experiences as critical to their subsequent understanding of new contexts or experiences. Based on the Kenyan example, we can justify why it is important to seek students' views on how they experience learning and on the nature of the learning experiences as students' views are a better way to access the real impact of the learning experiences that teachers design. However, for the case of this study, this argument is situated against the contextual backdrop of a school curriculum and pedagogical culture, which are based on traditional exam-driven and highly teacher-centered models (Tsuma, 1998).

The Kenyan Education System

The Kenyan education system operates an 8:4:4 framework, that is, 8 years of primary education, 4 years of high school and (a minimum of) 4 years of university education (Amutabi, 2003). At the end of the primary and secondary phases, students take national examinations, Kenya Certificate of Primary Education (KCPE) and Kenya Certificate of Secondary Education (KCSE) respectively (The Kenya National Examinations Council, KNEC, 2004–2005). KCSE enables the students to join universities, middle level colleges, or polytechnics. The national language of Kenya is Kiwahili – examined and written in Kiswahili. However, all other examinations are written in English as it is both the official language and medium of instruction in Kenyan schools (KNEC, 2004–2005). Selection to high school and university in Kenya depends on a student's performance on KCPE and KCSE respectively. Due to limited places in these institutions, admission is very competitive. Although there is an effort to make the educational standard uniform in all high schools, there are still three categories of public high schools: *National, Provincial*, and *District* schools. Admission to these schools is largely based on how well one performed on KCPE exam.

Of the primary school graduates about 47% are admitted to secondary schools (Ministry of Education, Science and Technology, Government of Kenya, 2004). These numbers fluctuate every year. Prior to sitting the national examinations, the students are subjected to rigorous testing and mock exams. In fact, throughout the years preceding the national examinations, testing is routine whereby teaching and testing are driven by past examination content. As eloquently expressed by Glogowski (2008) in a blog where he comments on his Kenyan experience:

> the Kenyan system of education is dominated by exams which play a crucial role in deciding the students' future. Results obtained in these exams determine whether or not the student can move on to the next grade, to high school, or post-secondary education. If the results are not high enough, the student is left without options (p. 1).

This observation is indeed a summary of the reality of the Kenyan classroom context. Faced with the task of helping students do well in these exams, the teachers adopt extreme teacher-centered approaches where note giving, *hunching* about possible areas on the exam, and drilling for exams characterize teacher pedagogy (Amutabi, 2003). This pedagogic culture places immense pressure on both the teachers and students. Quite often both the teachers and students examine the syllabus, identify areas that are likely to be tested at national level, and search previous exams for questions that could be repeated in forthcoming exams. According to Shujaa (1994) cited in Keriga and Bujra (2009), "... the rote learning and mechanical studying to pass examinations has replaced all the necessary ethics of studying to develop a deep understanding and mastery of one's life and environment" (p. 13). This situation makes teachers less receptive to innovative pedagogies, and they make no attempt to place the responsibility for learning on the students where teachers become facilitators of student learning as opposed to transmitters of knowledge. It is common to find community leaders and parents demanding the removal of a teacher from their local school for not having produced the results expected of him or her. This is clearly illustrated by a report in *Education International—Kenya* at http://www.ei-ie.org/en/news/news_details/2053:

> The Kenya National Union of Teachers (KNUT), one of EI's national affiliates, has condemned the surge of violence against teachers following the release of the results for the national Kenya Certificate of Primary Education examinations (KCPE). In the days following the issuing of the results in late December 2011, reports emerged of parents threatening, assaulting, and chasing teachers away from schools that performed poorly. Several teachers are in the hospital with serious injuries. A number of schools across the country have closed down. While respecting the rights of parents to express their dissatisfaction with the outcome of the examinations violence against individual teachers is not a legitimate or acceptable response.

This threat of removal results in the teachers feeling vulnerable, and hence, they resort to implementing drill and practice sessions on how to pass exams (Keriga & Bujra, 1999). In a very subtle way, teacher performance or productivity is determined by how many students pass their respective subjects or courses.

An implicit and prevailing attitude among high school teachers is that they do not need new teaching methodologies, and making science relevant to the students is regarded as superfluous to examination performance. Inherent in this view, is that the classroom is the best place to equip students with the knowledge needed to pass the examination. Visits to authentic science learning environments are considered unnecessary and time-wasting. The practice in most Kenyan classrooms is for teachers to subject students to primarily exam-content-laden lectures. This is further compounded by a limited number of university places for which high school graduates compete. And, by implication, the teachers themselves are in a way competing since their credibility is determined by how many successful graduates join universities. For example, as reported in one of Kenya's mainstream newspapers, the "Daily Nation" (2009), about 17,000 out of 305,000 high school graduates were admitted to Kenyan universities for the 2009/2010 academic year.

Currently, the Kenyan curriculum is still modeled on an outdated, decontextualized practice (King & Ritchie, 2012) that is irrelevant to students (Anderson & Nashon, 2009; Tsuma, 1998). Also, it lacks relevance in terms of connections to work places such as the *Jua Kali*, where 75% of high school graduates are eventually employed (McLeanand & Kamau, 1999). Furthermore, there is lack of real mechanisms to help facilitate Kenyan industrialization. Confounding this problem is the fact that there is no reported research that considers Kenyan high school students' views of learning mediated by integrating classroom science with the science embedded in the real world.

As part of the context described briefly above, several key assumptions underpinned the research investigation including: (1) understanding how students see the world and harnessing this understanding to enable the development of better science learning experiences; (2) examining Kenyan students' views of science learning through integrated classroom-Jua Kali based science curriculum unit is one way to further enlighten our current understandings of how people make meaning of the world; (3) recognizing the relationship between classroom science and the science embedded in the Jua Kali production activities is a key step towards the attempt to revolutionizing Jua Kali sector to the benefit of Kenya; and (4) understanding Kenyan students' views of learning science through and from their local contexts will be part of informing education programs through which the majority of Jua Kali artisans are prepared.

The outcomes of the investigation are important as they can help teachers to better plan and implement science instruction that resonates with, as well as challenges or enhances, students' pre-conceptions about the nature of science curriculum in the light of contextual learning of science both in Kenya and elsewhere. Although these might seem rhetorical, the important point is to evoke or provoke debates about the nature and relevance of science whether it is about scientific literacy or relevance in terms of preparing for civic life youth for whom higher education is not a viable option. Therefore, research in such contexts as Kenya could provoke debate about curriculum reform that responds to the yearning for relevance in science.

Consistent with the key assumptions expressed above, the study investigated the questions: What are the Kenyan students' views of (1) contextualized science learning in culturally-relevant real-world science curriculum unit (9 weeks) that linked classroom and Jua Kali activities; (2) their science curriculum and instruction after participating in the science unit; and (3) the science unit experience 1 year later?

Theoretical Framework

This study was grounded in socio-cultural theories of knowledge construction (Kozulin, 2003; Rogoff, 1990; Vygotsky, 1978) to interpret Kenyan students' views of contextualized science learning experiences. Consistent with these theories, learning can be envisioned as occurring holistically and not in isolated contexts (Ausubel, 1963, 1968; Bodner, 1986; Novak & Gowin, 1984) and as a dynamic process developed through experiences that are interpreted in the light of the learners' prior knowledge (Driver, Leach, Millar, & Scott, 1997; Hodson, 1998; Mutonyi, Nashon, & Nielsen, 2010; Nashon & Anderson, 2004), attitudes, and personal background (Guerts, 2002; King, Chipman, & Cruz-Janzen, 1994; Lave & Wenger, 1991). By learning we mean the processes of recognition, evaluation, and revision of personal conceptual frameworks by the learner, which develop continuously within and across a multiplicity of socially situated settings (Beghetto & Baxter, 2012; Driver, 1983; Gergen, 1995; Lave, 1988; Mintzes, Wandersee, & Novak, 1997, 1998). Moreover, according to Zimmerman (2012) learning is a sociocultural act that involves thinking. Thus in her view, thinking is intertwined with cognitive, social, and contextual factors. Further, citing Hutchins (1995) and Pea (1993), Zimmerman insists that analysis of learning should take into account the artifacts and the people with whom the learner interacts during learning. Therefore in this study, learning is understood to include transforming student views or perceptions, which develop continuously within and across a multiplicity of socially situated settings (Driver, 1983; Gergen, 1995; Mintzes et al., 1997, 1998). Moreover, what is especially central to this study is our understanding that students' perceptions or views rarely develop instantaneously, but rather through catalytic events that connect classroom science to the real world which have the potential to gradually affect their views or perceptions over a period of time (Anderson, Lucas, Ginns, & Dierking, 2000; Dexter, Anderson, & Becker, 1999; Maskiewicz & Winters, 2012; Mutonyi et al., 2010). The Dexter et al. study showed that teachers' use of technology influenced their perception of the impact of computers on their classroom practice. This claim is well documented, with many educators (e.g., Collins, 1991; Means, Olson, & Singh, 1995; Mehlinger, 1996; Newman, 1992; Sheingold, 1991) claiming technology to have the potential to be a catalyst for reforms in education. Further, the socio-cultural identities of individuals and the groups (class, school, ethnic, or nationality) to which they belong strongly influence their perceptions or views of the world around them (Bell, Lederman, & Abd-El-Khalik, 2000; Endreny, 2012; Lederman, 1992; Nashon, 2003, 2004). This socio-cultural framework is further complemented by contextual learning theory (Hull, 1993) which envisions learning as occurring only when learners process new information in ways that make it meaningful in their frame of reference. According to Hull, this approach assumes that the mind naturally seeks meaning in a context by searching for relationships that make sense and resonate with the students' cultural backgrounds or identities. Accordingly, contextual learning is organized in ways that allow students opportunities to engage in real-world problem solving activities (Karweit, 1993). Learning in meaningful contexts is determined to be educationally effective (Carraher, Carraher, & Schleimer, 1985; Lave, Smith, & Butler, 1988; Ratcliffe & Millar, 2009; Zimmerman, 2012). Meaningfulness is empowering as demonstrated in Upadhyay (2005a, 2005b) study on students who are empowered to continue with schooling. Upadhyay believed that localizing teaching is empowering, especially when incorporating students' lived experiences; although she cautions that this can be risky since it involves negotiation. But, as Resnick (1987) noted, decontextualizing science learning could be viewed as meaningless for students since it lacks relevance outside of the school. Zimmerman (2012), concerned with the lack of studies that documented the ways youth engage in science practices in home settings, framed an ethnographic study involving one female student who was caring for animals at home and became interested in the relevant science. In the study, Zimmerman used a composite framework that included learning as "participation in practice" (p. 598) perspective. This perspective views learning to be a sociocultural act. Thus, Zimmerman's ethnographic analysis of the girl's learning revealed that she engaged in four competences: (1) observational inquiry, (2) media use to understand animal behavior, (3) experimentation with feeding to keep her animals healthy, and (4) manipulation of her animals and animal-related artifacts to create routines and safe indoor habitat. By engaging these competences as Zimmerman reports, the girl in the study accessed new science learning both in school and in afterschool settings.

This is consistent with Gay's (2002) suggestion that, "... when academic knowledge and skills are situated within the students' lived experiences and frames of reference, they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly" (p. 106). The consequence of this is likely to be improved achievement since they would have been taught from their own cultural and experiential filters (Au & Kawakami, 1994; Foster, 1995; Gay, 2000; Hollins, 1996; Johnson, 2011; Kleinfeld, 1975; Ladson-Billings, 1994, 1995). Some experiences can be obtained through deliberately organized fieldtrips purposed for student learning. Although the Kenyan science curriculum recommends the use of fieldtrips, teachers rarely exploit the potential to benefit student science learning. It is worthy to point out that school field trip venues including Jua Kali centers or places are important learning sites where students can be allowed and encouraged to manage and direct their own learning (Griffin & Symington, 1997). Furthermore, there has been a developing literature base on learning in out-of-school settings (Anderson et al., 2000; Anderson & Nashon, 2007; DeWitt & Hohenstein, 2010; Nielsen, Nashon, & Anderson, 2009; Ramey-Gassert, Walberg, & Walbert, 1994; Rennie & McClafferty, 1996) that demonstrates this assertion. As Piscitelli and Anderson (2001) have argued, there is a need among teachers to understand how to capitalize more effectively on field-trip experiences and their classroom environments. Thus student field trip experiences are very much under-realized in terms of their potential to develop rich and detailed cognitive understandings as well as their capacity to contextualize science taught in the classroom. The frameworks and related literature discussed above were important in the interpretation of the data sets around students' views of science learning through integrated classroom-Jua Kali experiences and their school science and instruction.

The current study is important in the sense that the experiences students have during field trips to out-of-school settings such as Jua Kali are very much under-realized in terms of their potential to develop rich and detailed cognitive understandings. Given this level of interest in and the potential of out-of-school settings to inspire student learning, teachers and educators need information to enhance the educational impact of field trip experiences. There is also a need for the wider education community to better understand the nature of learning in out-of-school environments. It is in this regard that investigating students' views of learning in such contexts is important since understanding their views of learning experiences in out-of school contexts such as Jua Kali and harnessing this understanding will enable the development of better learning experiences. Examining the students' views can enlighten teachers' understandings of what students think about the experience of learning in out-of-school contexts. Understanding students' views of learning contextualized science will inform education programs that frame holistic learning beyond the confines of a traditional classroom setting. Moreover, the study's findings can provide baseline information for framing more longitudinal studies that can follow participants into post-secondary education to investigate the extent to which they use local contexts in science learning. Other studies that could benefit from a study such as this would be to follow those students who eventually work in Jua Kali to understand the impact they might have on the quality of Jua Kali products, production processes, and innovations. As such, this article discusses a study that provides in part the needed information to begin to fill the void in literature.

Methodology

An interpretive frame (Creswell, 2009; Green, Caracelli, & Graham, 1989; Tashakkori & Teddlie, 2003) was important to selecting data collection, analytical, and interpretative tools and understanding the students' views or perceptions. The aim was to access these views or perceptions of learning through a series of activities embodied in a 9-week science curriculum unit. The research team hoped to gain a holistic understanding of the Kenyan students' views of contextualized science learning and school science curriculum and instruction as expressed in words or actions (Boulton-Lewis & Wilss, 2004; Miles & Huberman, 1994). In the context of the current study, the aim was to explicate the way students understood, accounted for, acted upon, and managed their learning through their views. An interpretive framework is based on the premise that individuals including students, teachers, and researchers construct their own reality of their world (Gergen, 1985; Richardson, 1997; Schwandt, 2003). They do this with the help of building blocks and methods available to them (Schutz, 1970). This interpretation of students' views of science learning experience and school science curriculum and instruction in particular settings, required case study methods. As an interpretive case study, the current inquiry involved interpreting students' views of the learning experiences and school science curriculum and instruction of only those who participated. As stated above, the case in this study is constitutive of Form 3 Kenyan students whose views of contextualized science learning in a 9-week culturally relevant real-world science curriculum unit that linked classroom and Jua Kali activities; their science curriculum and instruction after participating in the science unit; and the science unit experience 1 year later were elicited and interpreted.

The study used 1-hour biweekly classroom observations per class recorded by our trained research assistants. Student reflective journal information was also compiled, and the researchers entered the data every 2 weeks to frame focus group interviews designed to elicit and elucidate students' views of contextualized science learning and school science curriculum and instruction. Prior to the first interviews which probed their initial views of contextualized science learning, the students completed a questionnaire that was intended to stimulate their thoughts and pique curiosity about learning science in this way. Traditionally, methods, and in particular questionnaire instruments, have been used exclusively as tools for data collection, a view that is grounded in the epistemology that methods have no effect on participants (Anderson, Nashon, & Thomas, 2009). However, in this study we intentionally used the questionnaire as a mechanism to stimulate students' thoughts and to pique their interests in contextualized science learning. Further, the questionnaire was used to increase students' capacity to become self-aware and articulate their views in an interview format (Anderson et al., 2009). The students' views of learning experiences and school science curriculum and instruction were elicited primarily through our analytical consideration of their reflections during interviewing.

The research team administered the questionnaire and follow-up focus group interview at the beginning of the 9-week science unit which was comprised of topics from the mandated curriculum that could be linked to or integrated with activities in the Jua Kali. These were followed by episodes of whole-class Jua Kali visits and follow-up classroom-based activities. All these learning experiences placed the students in a position to participate in two more interviews. One interview was administered immediately after follow-up in-class activity, and the other took place 1 year later. These interviews sought to elicit, interpret, and understand the students' views of contextualized science learning and their school science curriculum and instruction. The longitudinal interview was conducted to gain an understanding of the experience's impact on students' views sustained long after its official conclusion. Moreover, it permitted an interpretation of students' views that were unbiased by the immediate halo effects of the initial experiences. The two latter interview data sets constituted the bulk of the data for interpretation in this article.

Prior to commencing the study, science teachers had been chosen from select national and provincial schools based on (i) willingness to participate in the study; (ii) involvement in teaching of the three main science subjects (Physics, Chemistry and Biology) to Form 3 (Grade 11), and (iii) willingness to participate in a 1-day workshop. The workshop involved clarification and discussion of the aims and nature of expected science discourses. The research team along with the teachers identified and discussed topics from the mandated curriculum that could be linked or integrated with Jua Kali activities as a nine-week science curriculum unit described below. In addition, they developed student reflective journals which included entries guided by the following questions: (1) What did you know about this topic before today's science lesson? (2) What do you now know that is (i) different from and (ii) same as what you already knew? (3) What aspects of Jua Kali production activities can be explained by what you leant about the topic in the science lesson today? (4) How can what goes on in the Jua Kali production activities help you understand better the topic you leant in the science lesson today?, and (5) What Jua Kali production activities would you like to know the science behind? In a way, this served as a form of professional development workshop.

Identifying and Organizing Curriculum Unit Topics During the Workshop

Before the study commenced, the research team and the science teachers from the four selected schools visited a Jua Kali site. They identified a variety of production activities and products that could be linked to school science curriculum or understood in terms of school science as well as pique students' curiosity and attract their attention to understand the embedded science.

In collaboration with Jua Kali artisans, the teachers and research team divided the site into ten production stations to ensure that during the impending 3-hour class visit, the students engaged in science learning through observation of production activities and products as they interacted with the artisans. This was followed by a 1-day workshop in which the research team and the teachers identified science curricula topics from each main science subject (Physics, Chemistry, and Biology) that constituted a 9-week or one term (May–August) science unit. Key topics and corresponding Jua Kali products and production processes are shown in Table 1.

As part of the workshop proceedings, the research team and the teachers discussed and agreed on procedures for implementing the science unit including developing a set of questions that guided student observation and discussions during the Jua Kali visit (Table 2) and follow-up in-class activity (Table 3).

Implementation of the rest of the unit required the students, whenever appropriate, to interact with their surroundings including Jua Kali to deepen their understanding of science concepts.

Implementing the Science Unit and Study

Implementation of the study began with 200 Form 3 (grade 11) students from four high schools completing a questionnaire that was used as a mechanism to stimulate students' views about contextualized science learning as well as increasing their capacity to become self-aware and articulate their views in subsequent interviews (Anderson et al., 2009). Form 3 students are a suitable choice for this kind of study because they were introduced to science concepts in previous grades, and due to the spiral nature of the Kenyan high school science curriculum, they are at a level that requires deeper understanding of science concepts in readiness for the high school exit exam the following year. They need to attain higher marks

Table 1
Science unit: topics for curricular and instructional integration

Physics

Curriculum topic I:

Work, energy, power and machines; law of conservation of energy; vacuum flasks; Fireless cookers

Jua Kali experience: Fireless cookers, hot pots, Jua Kali Jiko, and Jua Kali ovens

Curriculum topic II:

Quantity of heat: Elements of conservation of energy; Pressure cooker

Jua Kali experience: Charcoal refrigerator

Chemistry

Curriculum topic I: Energy conservation, organic fuels, e.g., graphitic charcoal

Explaining energy conservation and wastage (efficiency) in the different types of Jiko; suggesting and justifying modifications to the types of Jiko to maximize energy conservation

Jua Kali experience: Local types of burners (Jikos): Three stones, Chepkube (the Kalenjin version of cooker), Jiko, Modified clay Jiko; fuels: Charcoal (Amorphous carbon), Wood charcoal, Animal charcoal (bones), Cow dung, and Msogoro (maize cobs)

Biology

Curriculum topic I: Animal Nutrition: Energy requirement in man and factors that determine energy requirement

Jua Kali experience: See cart pushers; chicks in the brooder with Jiko as a source of heat

Curriculum topic II: Respiration: Anaerobic (fermentation)

Jua Kali experience: Processing of yoghurt, cheese, mala (sour milk), and beer; Biogas

Curriculum topic III: Ecology: Energy sources including solar and conservation

Jua Kali experience: Solar cookers, sterilization of drinking water, Heat energy produced during germination, hot food storage baskets

in science exams as the science subjects appear to be the gatekeeper for university entry into local lucrative professional degree programs such as medicine, engineering, architecture, and land economics.

For purposes of tracking, 20 students were selected for group interviews (four select groups of 5 students, i.e., 1 group from each school). These were self formed student groups that teachers in their respective schools considered to be articulate in terms of expressing their thoughts while at the same time representing class diversity in terms of academic ability and ethnic backgrounds. According to the teachers, group formation was more complex and

Table 2
Student's interaction with artisans—guiding questions/tasks during Jua Kali visit

1. What are the main materials that you work with?
2. What is the source of the materials you use in your products?
3. Are the materials recyclable or reusable?
4. Are there other materials that can be used for the same purpose?
5. Why have you not used these others?
6. Show us the different types of Jiko/products?
7. Which ones are commonly bought and why?
8. What other products besides the Jikos have you produced?
   (i) How well does each product sell?
9. What properties do you consider when choosing these materials?
   (i) How durable are these products?
10. Can they be improved upon?
11. How suitable are the final products to the user?
12. What possible improvements or alternatives are considering?

Table 3
Post-Jua Kali visit classroom questions/tasks

1. Out of the total number of production stations you visited, identify three production activities that you found most interesting and where you learned the most. Rank them in order of merit and give reasons in each case
2. Out of the activities in the three identified Jua Kali stations in (Q. 2) above, identify the product that requires the highest skill level to produce and give reasons for your suggestions
3. Out of the three Jua Kali production activities identified in (Q. 2) above, identify one that gave you the most important learning experience and justify
4. What product in Jua Kali evoked your science knowledge most and why?
5. How, in your view, can the production process and the final product identified in (Q. 3) above be improved?
6. What personal strategies of learning science does this way of experiencing science (in Q. 6) evoke?
7. Make a 10-minute class presentation of your group responses to Qs. 3, 4, 5, and 6. Decide on a presentation strategy where all members participate

eclectic. Some groups had students with similar ethnic backgrounds and in some cases, the teachers allowed these groups because of the perceived comfort in asking peers questions and engaging them in discussion. Other groups were diverse in ethnic composition. Ironically and not surprisingly, according to the teachers, and as we later noted, these were student groups who could express themselves clearly in English. The teachers described these groups as being comprised of students who were performing academically at an average to above average level with a very high potential to enter college or university. In our view, these are suitable targets to influence student views of science learning in local contexts with the hope that one day they will be in responsible policy making positions and could hopefully have a favorable consideration of this kind of curricular approach. We believed that if brighter students who succeed in the current exam-centered system of Kenya can develop positive views about contextualized science curriculum and instruction, then, there is a strong possibility for teachers and other stakeholders to accept the cultural shift in curricular and pedagogical organization of science with a focus on local context and the embedded science.

Pre-Jua Kali Visit Experiences: Questionnaire and Interview

As earlier stated, the questionnaire and 1st interview were used as mechanisms to stimulate students' thoughts about their learning and self-awareness and articulate their views. The 20 students were interviewed after completing the questionnaire and prior to the Jua Kali visit to further prepare them to be metacognitive about their learning in the science unit. In the first interview, participants were asked questions such as: what are your learning expectations of the coming Jua Kali visit? What can you say about the questionnaire? What questionnaire items aroused your views about learning in Jua Kali? This was followed by whole-class visit to Jua Kali. Moreover, understanding from the questionnaire and the initial post-questionnaire interviews, Jua Kali visit experiences, and post-Jua Kali visit in-class activity allowed the research team to develop and implement the follow-up interviews that probed deeper into students' perceptions (see Supp. Info. Appendix 1 for semi-structured interview guides).

The Jua Kali Visit

During the visit, the 50 science students from each school worked in groups of five and engaged in conversations (guided by the questions in Table 2) with Jua Kali artisans for

3 hours and visited as many of the ten stations as time allowed. The mapping of the stations, as has been already described, ensured richness in variety of products and production activities (see Figure 2).

All the selected groups' experiences included conversations with Jua Kali artisans as they sought information about the Jua Kali products and production activities (guided by the questions in Table 1). A day after the Jua Kali visit experience, the science classes participated in a 1-hour in-class activity (Table 3).

Post-Jua Kali Visit: The In-Class Activity

The in-class activity required students to work in their respective Jua Kali groups on tasks that required them to discuss their learning experiences guided by the questions in Table 3. These tasks included selecting with justification three production activities at the Jua Kali that they found most interesting and from which they learned the most. In addition to attending to the direction of the other questions in Table 3, the in-class activity culminated in students preparing a 10-minute class presentation on how the production process and product could be improved. Thus, the process of visiting a local Jua Kali and developing and implementing related in-class activities served as a possible model pedagogy for subsequent unit lessons.

Post-Jua Kali Visit: Interviews

The 20 students (one select group of five students from each school) participated in two post-Jua Kali visit interviews: (1) immediately after the first in-class activities (1.5 hours 2nd interview) and (2) 1 year later interviews (2 hours 3rd interview). Informed by classroom observation experience and reflective student journal entries, the focus group interviews probed the students' views of learning science that integrated both classroom and local context experiences, such as those at the Jua Kali. The questions were open-ended as the idea was to provide a forum where the students expressed their views of how they experienced learning in this way and their thoughts about the nature of Ministry of Education prescribed science curriculum and instruction which their teachers were implementing (see Supp. Info. Appendix 1 for semi-structured focus group interview guides). The questions ranged from seeking the students' views about effective learning groups to the nature of curriculum and instruction and personally preferred modes of learning including how these differed from what their teachers preferred.

Both interviews with the four select groups of students were audio and video recorded for reviewing and transcription. Thus, there was a total of 14 hours of recorded post-Jua Kali and 1 year later interview data. This translated into 56 hours of transcribed interview data. In this article, only interview data sets (post-in-class and 1 year later) from one exemplar group of five is used to discuss and illustrate insights emergent across the groups (see Supp. Info. Appendix 2). Although the insights were common across the groups, the exemplar group is selected for this discussion because of its members' diverse ethnic backgrounds and their ability to articulate their thoughts in English clearly and elaborately.

The Rest of the Science Unit

Drawing from experience and understanding from the pedagogy modeled above, the teachers and students similarly implemented the rest of the nine-week science curriculum unit. Whereas no formal Jua Kali visits were organized for subsequent in-class learning discourses, the students were required to visit Jua Kali sites of their choice where they interacted with production activities and products that benefited their learning and class discussion.

Data Analysis

It is worth pointing out that the authors participated in the initial modeling of contextualized science experiences including familiarity with the classroom and Jua Kali settings. Besides, one of the authors was born and raised in Kenya and has great appreciation for local socio-cultural practices. The authors who have expertise and long experience in qualitative research worked closely with and offered informal training to other research team members. This included conducting focus group interviews and transcribing the interview data into typewritten transcripts (Miles & Huberman, 1994). The resulting thick descriptions of interview data were sifted through and in some cases, reconstructed to identify evidence of students' views or perceptions of contextualized science learning and of their school science curriculum and instruction before common patterns or themes were interpreted. This was necessary since the nature of the semi-structured interviews flowed as conversations, and the reconstruction of conversational data was necessary to organize the students' views with an additional level of logical coherence. Following this, the analysis of the two interview data sets involved examining and categorizing the respective interview transcripts using a thematic approach (Merriam, 1998; Miles & Huberman, 1994) to address the research questions (Miles & Huberman, 1994; Yin, 2003). This was a rigorous process where the research team regularly exchanged their individual insights via email, and met face-to-face for whole team meetings to discuss and compare analyses that resulted in the development of a collective interpretation of the data sets (Stake, 1995). The process involved several meetings of listening to interview video clips and reviewing of interview transcripts, comparing and contrasting student statements, and in-depth research team discussions of the themes that emerged across the two data sets. These meetings took place immediately after the Jua Kali experience and the one-year later interviews. The rationale for this approach was to elucidate the themes that were evident and manifested following the Jua Kali experience and remained stable in the students' views 1 year later. Each research team member generated patterns across the two interview data sets. Team members met to share their individual patterns and description or supporting phrases from the interview transcripts. The team meetings involved collapsing or expanding the patterns or statement categories from the interview data sets. The process was guided by the two research questions. Supporting Information Appendix 2 shows a summary of themes and how each theme was characterized. This resulted in four key themes that were evident across the two focus group interview data sets, which are discussed and supported by verbatim quotes or excerpts from the exemplar group, and are considered by the authors to represent the voices of the participants (using pseudonyms).

Findings

Four key emergent themes which were discerned from both post-Jua Kali (2nd interview) visit and 1 year later interviews (3rd interview) with the 20 select students who are illustrated and discussed below. The themes are a result of comparing and contrasting each team member's themes and combining them to reflect the core messages or views expressed by the 20 students in the interview responses. Thus, the themes illustrated and discussed below are specific to the group of 20 students. The initial themes (see Supp. Info. Appendix 2) were further refined to respond to the research questions guiding this article. These include: (1) Richness of Jua Kali in scientific phenomena and embedded science; (2) Lack of meaningfulness and relevance in existing science curriculum and instruction model; (3) Resonance of group and real life learning with students' preferred learning modes; and (4) Metacognitive assessment of often-used and contextualized science-modeled learning strategies. These four themes are elaborated below by illustrative quotations from exemplar focus group interview data sets. The quotations are selected from a larger body of dialogue with individual students in the context of the focus group interview with the purpose of illustrating the themes. Pseudonyms are used to protect the students' identities.

(1) Richness of Jua Kali in scientific phenomena and embedded science

Sifting through the interview data revealed certain words or phrases that pointed to expression of awareness of the richness of Jua Kali in scientific phenomena and embedded science, which in the students' view were understood through interaction with the Jua Kali artisans, products, and production activities. As indicated in Supporting Information Appendix 2, the following characterized the 20 students' views: Post-visit interview: Artisans used scientific terminology, for example, high and low density plastics; Source of artisans' knowledge inquired; Recognition of disciplinary content in Jua Kali, for example, pollution & Biology; heat transfer & physics; Connections to classroom knowledge—constantly referring to what the teachers told them; Connecting classroom science with home items and Jua Kali; and Curiosity on how to improve Jua Kali products. One year later, the following were also discerned as reinforcing views expressed in the post-visit interview: Always looking for relevance to the world outside the classroom; Seeing science differently (attitude affected); Always amazed with ways artisans use disciplinary knowledge in practical ways; Validation of classroom knowledge; and Connection of textbook knowledge with outside world/Jua Kali.

Although framed differently by all 20 students who participated in the study, reflecting on the above descriptors, there emerges a sense that these students expressed a strong orientation or disposition towards *learning* science using their local Jua Kali as reflected in their post-visit interview where they expressed excitement and appreciation of how the Jua Kali visit experience affected the way they understood science. In this regard Mary noted: "The artisan was talking about high-density plastic and low-density plastic . . . and now I am thinking, how did he get this knowledge?" This is an expression of surprise by Mary, since she realized that the Jua Kali artisans employed scientific principles to whatever they were making. The terminology she refers to describes the topic she might have learned in class and not have encountered until the Jua Kali visit. On her part Monica offered: "You see in the Jua Kali pollution connected with Biology; . . . heat-transfer connected with Physics, [and] Chemistry . . . with plastics . . . this reminded me of our biology teacher talking about plastics." In fact Monica is even more explicit than Mary by admitting that she was able to see the classroom science embedded in the Jua Kali. On the other hand Enid found that the context evoked questions she always had about the Jua Kali products she only saw in her home. It seems this was the moment she started to see connections between school science and the science embedded in the home and Jua Kali environments. Thus she offered: "My mother uses the Jiko (charcoal stove) at home, however, it's not so durable. I've seen them break, and I've found myself wondering how to make them better. Also, the fact that they can be improved further really made me think, 'How is it that they break?' . . . And I'm saying, 'Oh, that is why it breaks'. . .". In the same vein as Enid, Joyce says "I was really fascinated by the science behind it. I never knew it involved such mathematics, physics and chemistry . . ."

The four students responded to the prompt question in ways that vindicated our earlier declared philosophical view that classroom knowledge should have relevance to real-world contexts; the Jua Kali to the science class, the home environment, and other aspects of the students' everyday socio-cultural worlds. Moreover, they are consistent with the theoretical framework's premise that catalytic events such as the

Jua Kali visit and the in-class follow-up activity seemed to ignite the students' realization and appreciation of this way of learning science. As premised in the contextual learning theory (Hull, 1993), learning occurs only when learners process new information in ways that make it meaningful in their frame of reference. Also, as elaborated in the theoretical framework, the mind naturally seeks meaning in a context by searching for relationships that make sense and resonate with the students' cultural backgrounds or identities (Hull, 1993). Furthermore, the students' views reflected the general organizing frame of contextual learning, where they were allowed opportunities to engage in the real-world learning experiences (Karweit, 1993). Finally, there has been consistent acknowledgement in literature of the benefits of learning in meaningful contexts (Carraher et al., 1985; Lave et al., 1988; Ratcliffe & Millar, 2009; Upadhyay, 2005a, 2005b; Zimmerman, 2012). Thus, the questions the students raised and the connections they seemed to make between the science they learned in school and Jua Kali activities served to further illustrate this point.

In the focus group interview format 1 year after the Jua Kali experience, the students were asked: "In what ways has the classroom-Jua Kali science unit experience affected the way you learn science?" Responding to the question: Mary was somewhat metacognitive when she said: "Whenever I started learning something in class, I would start thinking, how can I apply this outside? I'm like curious to get out there to find out where this has been applied in life and how it can also be applied if it has not yet been applied." In her response Monica felt impacted by the experience by saying: "You know it's changed my attitude towards science! How those artisans use chemistry in a practical way that works in life. It's changed my attitude. I never knew how science could be applied like that." In the same vein, Enid vindicated what we consider to be a tenet of good science pedagogy, learning science and doing science (Hodson, 1998). Thus, she said: "When you go out there and see it in practice, you can see that this thing actually works." But according to Joyce, this was a new revelation when she said: "[Before,] I thought some things are just for the textbook . . . but when I went to the Jua Kali I came to see 'oh' this can happen."

It appears that the contextualized science experience influenced the way the students approached science as illustrated in their views a year later. This theme around awareness of connection of science beyond the bounds of the classroom was evident following the Jua Kali experience, but more significantly became broadly a part of the perspective discerned from the 20 students' views on contextualized learning of science. As has already been argued, perceptions of industrialization (embodied in science and technology) and implied in the Kenya Government vision (The 1997–2010 Republic of Kenya Master Plan on Education and Training, MPET, 1998) can only evolve from relevant local contexts. Therefore, contexts such as Jua Kali can be viewed as a significant part of an enabling motive for transforming the locally evolving industries through science and technology in any country. Consequently, to influence students' views of contextualized learning of science required engaging them in science discourses that linked classroom science to the real world of Jua Kali activities. In other words, influencing the students' views or perceptions required learning enablers that were situated in the students' socio-cultural environment (Jua Kali). For example, in the case of Mary, the desire to discover how she can apply her in-class learning to the outside world; for Monica, this was a revelation that might not have been possible were it not for the opportunity offered through the contextualized science learning project; and for Enid and Joyce, it appears that they were always under the impression that some of the science in textbooks or classroom cannot be applied. When reading their comments carefully, one is tempted to think that the Jua Kali experience affected their worldviews of science in regard to relevance. These students seem to imply that they recognized, evaluated, and revised their personal conceptual frameworks, which in our view developed within and across a multiplicity of socially situated settings (Driver, 1983; Gergen, 1995; Lave, 1988; Mintzes et al., 1997, 1998). The social setting in this regard is the Jua Kali where they interacted with artisans.

(2) Inadequacy of the conventional model of curriculum and instruction
This theme was a refinement of what the research team members detected from students' interview responses immediately after the in-class activity and 1 year later. The immediately after in-class activity interview responses conveyed the following: fun of science was experienced; science is not just for scientists; science can be learned outside the confines of laboratories; rationale questioned for not including Jua Kali type experiences in syllabus; sensitivity to a need to understand what is around them; revelation of lack of creativity in classroom discourses; and the undermining of reading books as the dominant mode of getting facts. Also 1 year later, the following were detected in the responses: the syllabus now makes sense; cramming never helped; syllabus restrictive; syllabus overloaded; peer discussion is beneficial; Jua Kali experience inspired skill of argumentation; and enhanced engagement of individual unique ways of learning.

The students seemed to realize that the existing science curriculum and instruction model was lacking in meaningfulness and relevance. However, they appear to find the strategies that were stimulated through the study's learning activities/experiences to be fruitful. In other words, relating science to Jua Kali products and production processes during the visit was meaningful. This is consistent with what Hull (1993) claims to involve the mind that naturally seeks meaning in a context for relationships that make sense and resonate with one's socio-cultural background.

During the focus group interview immediately after the in-class activity, Fatima, Joyce, and Mary indicated that they came to realize and experience the pedagogical and curricular disconnects between school science curriculum and instruction and their modes of learning after experiencing the integrated classroom-Jua Kali science. The sentiments were elicited through a general question during the first post-Jua Kali visit interview (immediately after the in-class activity) that inquired whether or not their expectations were met. The question evoked their personal reflections regarding their individual dissatisfaction with traditional curriculum and pedagogy of the science classroom. Thus, Fatima said:

> I think the experience of learning science at the Jua Kali surpassed my expectations, because for the first time we are seeing that science is fun. You read books and do exams [and] think of science as just scientists in laboratories or geniuses, but we have seen it in real life . . . usually, we just learn science in the class and the lab, and do exams and go home, we never get to see science in real life.

In Fatima's view it never occurred to her that science exists beyond the classroom, textbooks, and laboratories. Also, that she had never made the connection between what was in school science and connections to the real world as previously modeled in the science pedagogy. Thus, she advised: "When they are making the syllabus they should make it with reference to what happens in our real lives—to what is around us—because we can then understand what is around us." In the same vein Joyce wondered: "I don't understand why the new syllabus does not include such wonderful [learning] experiences as the Jua Kali." Mary seemed to reveal the problem with the existing pedagogy by saying: "In our normal science classes, we are not given an opportunity to display our creativity at all! You [only] read the book and get the facts.''

Again, going by these students' sentiments, it can be taken that the integrated classroom-Jua Kali science unit experience impacted their perceptions of the way learning should be and ought to be practiced. The students reveal newfound learning experiences that seem to resonate with their expectations and the relevance of applications of science to their socio-cultural worlds. For instance, Fatima suggests that for the first time they saw science as fun; Joyce questions why the syllabus is not connected to real life context; and Mary reveals the lack of opportunities to exploit their creativity. It is important to note the collective use of ''we'' by most of the students. This is reflective of the social nature of the students and their shared perceptions. This is consistent with the socio-cultural framework that points to the nature of these students' views or perceptions as being socially and culturally shaped (Ngara, 2007; Owuor, 2007). Thus, the collective voice of the group expressed views about the need to make science teaching more relevant and meaningful to the students' everyday socio-cultural worlds. One year later, the students were asked to give examples of how their approach to learning science changed during the year. Again, Fatima seems to have developed a sensitivity to trying to understand the world around her:

> I have come to realize that what is in the syllabus is difficult and meaningless to me but the project helped me start asking myself questions about what I see around me. (...) There was also a time when we were told in Chemistry to remember the first 20 elements just like that and it was so hard. I crammed and still failed. Afterwards, I made a song about the 20 elements and me being a person who really enjoys singing—it has become a part of what I can remember easily.

Moreover, Joyce realized the importance of peer consultation; and Mary appreciates the power of argumentation as a learning strategy while still having misgivings about the syllabus's lack of relevance to her surrounding:

> This last year I realized that the syllabus has a lot of material to be covered and I learned how to cover the material differently. I learned that I could count on Monica for research in the library. (...) She does a lot of research and she informs us when we work as a group and this way we learn things in the syllabus before the teacher teaches us.

And, according to Monica, she and her colleagues had the opportunity to use their unique ways of learning including use of songs to remember challenging content:

> I still find the syllabus not allowing us to understand what is around us. But from the Jua Kali experience I have learned to argue with my friends about why certain things happen the way they do around us. When I argue many times, I cannot forget the things we argued about. Also, as we were encouraged in this project last year to use our own learning ways, we later had a topic in biology and I learned the whole topic by making a song and singing the song, and, . . . just going by the song, I remember the answer.

Monica further revealed how she often overcame the challenge of remembering something in biology and shared the strategy she employed with her friends to overcome this difficulty—a strategy that she claimed the syllabus did not seem to recognize or by implication, the biology teachers never bothered to explore:

> Remembering some of the names in biology is very difficult and the syllabus does not tell you how to remember them easily. So, me and my friends give the topics our names or use songs so that we can remember very easily. (. . .) We have found it to be helpful in exams.

The views conveyed in the statements from Fatima, Joyce, Mary, and Monica point to the need to organize science instruction by capitalizing on students' local socio-cultural contexts and modes of learning to enhance their understanding of science concepts. Based on the statements 1 year later, one can see an appreciation of the different strategies that help them learn science including questioning, anthropomorphizing, researching, argumentation, and discussion. Although these are explicitly conveyed in the above excerpt and are unique to individual students and thus, require a conducive learning environment, it was the same impression that we received from the other groups. It is heartening to note that some of the students acknowledged the benefits derived from their peers' unique learning strategies; for example, in Monica's view, her group devised singing to remember biology concepts, which as she suggested ''. . . the syllabus does not tell you how to remember them easily.'' This further reinforced the value Fatima, Joyce, Mary, and Monica found in their unique individual learning strategies such as making and singing songs that embody the science concepts intended for learning. This, in our view, undermined the traditional individualized rote learning strategies dictated by the nature of their school science and instruction. The use of singing by Fatima, Mary, and Monica, which is in the same vein as the participants in Nashon's (2003, 2004) study, who spontaneously generated anthropomorphic analogies during physics instruction in Kenyan classrooms, elicits a strong temptation to conclude that there are unique and authentic ways of learning science. The teachers and curriculum developers in Kenya and elsewhere, where this could apply need to elicit and tap into the students' unique learning strategies by offering opportunities through contexts such as Jua Kali to evoke such natural strategies.

(3) Resonance of group and real life learning with students' preferred learning modesThis theme was derived from elements of phrases discerned from the students' interview responses. From the interview responses after in-class activity, the following were discerned: no opportunities for group learning in class; promotion of individual learning; cramming is not understanding; crammed knowledge easily forgotten after serving specific purpose; project promoted thinking and is better for exams; and discussion in groups very helpful. These indicate what is not happening in their classrooms as well as imply what they might prefer that is not provided such as working in groups. Similar views are conveyed in the 1-year later interview responses including: trusted mate as point person for discussion; bonding after Jua Kali modeling of group learning; recognized each other's strengths and weaknesses; peer teaching helps mastery; and learning from peers what you cannot learn from teachers. In general the students who were interviewed seemed to have realized that the group learning strategy and real-life experiences modeled through the integrated classroom-Jua Kali science curricular experience resonated with their preferred modes of learning. It also conveyed the impression that learning-by-rote strategy which they often practiced was untenable or undermined.

Moreover, there appeared to be tension between the traditional learning strategies the students often practiced and embraced, and the newly experienced integrated model of learning. This was possibly reinforced by the contrast between their teachers' pedagogy and what was modeled during the integrated Jua Kali science unit, which seemed to tap into their social culture of learning, which according to Ngara (2007) and Owuor (2007), resonates well with African ways of knowing. This was conveyed in the after in-class activity interview when the students were asked how often they were given the opportunity to engage socially in group learning and how working in groups might have helped them learn. In response Mary stated: "We are not given the opportunity to engage in groups and be creative in class, but I now think you can really only understand the science when we share our ideas with each other as we did at the Jua Kali." Everyone in the groups agreed. This was emphasized by Fatima who said:

> We are not given an opportunity to display our creativity in groups at all! You [only] read the book alone and get the facts! Students study individually and cram for the exam, but, do not understand. When you do something in theory and then see the practical ... in real life, like in Jua Kali and discuss with friends, it sticks.

This seemed to result in everyone wanting to comment on something they now realized was never utilized by their teachers. Enid offered: "For example, we used to just say in a chorus, 'Clay is a good insulator' repeatedly, which is just cramming, but when we see it in real life and discuss together as in Jua Kali, our knowledge doesn't get forgotten." Therefore in Monica's view the project offered opportunity for this kind of learning: "We think this project [the integrated model] can help you learn better and do better at exams because it forced us to think very hard about the science ideas by arguing together with our friends."

Fatima's sentiments here, exemplify the general sentiments expressed by most participants. Through Fatima's response, one sees the awareness in the students of the inadequacies in the learning strategies they often employ and the fruitfulness, joyfulness, and satisfaction of learning mediated through social engagement. According to Ngara (2007) and Owuor (2007) engaging in groups is the way the African is socialized hence the relevance of the study's framework. According to Gay (2002), "... when academic knowledge and skills are situated within the lived experiences ... they are more personally meaningful, have higher interest appeal, ... learned more easily and thoroughly" (p. 106). Consequences include improved achievement as they are situated and taught from their own cultural and experiential filters (Au & Kawakami, 1994; Foster, 1995; Gay, 2000; Hollins, 1996; Kleinfeld, 1975; Ladson-Billings, 1994, 1995). For instance, Mary complains of the lack of opportunity for this approach to learning; Fatima also voices dissatisfaction about the lack of group learning strategies in her classes; Enid seems to suggest getting the facts from books but connoting rote learning; and Monica reveals the benefit gained from group learning which is modeled in the project.

One year later, there is further realization and appreciation of other powerful learning strategies which the students have put into practice, and they seem to experience the benefits. Some are expressed in the preceding quotations. But, more so, this appreciation can be found in statements that were in direct response to a question from the research team who asked the students what lessons they might have learned from the way the 9-week classroom-Jua Kali science unit experiences were organized. In particular, they singled out working with a group of trusted peers which they expressed in some cases metaphorically. From group learning strategy modeled in the 9-week contextualized science unit Mary says: "I have continued to think more about working together and have come to think, if you have a sister [trusted classmate] and you have a problem, the first person you think of is your sister." Monica reinforces this by saying:

> These four classmates of mine are now like sisters to me. If I do not understand something or I have something to share they'll be the first ones to know because they're close to me. The Jua Kali visit and working together really helped us enjoy working together.

And, Fatima says: "I have now trusted our group since last year and if I have an idea I like and I know one of them knows I have the idea, I can actually make them learn it." Moreover, in a metacongnitive reflection, Enid says: "The experience of last year has made me feel happy to learn something from my friends and don't even bother to ask the teachers." And as if to summarize it all, Joyce reveals: "I have now realized that you learn from your sisters what you can't learn from your teacher."

The group learning embodied in the study's learning activities/experiences seems to offer effective alternatives to, and, perhaps challenged, what Fatima and others had experienced such as cramming without understanding (*rote learning*). Furthermore, in the typical classroom pedagogy, the students are denied the opportunities for group learning; a strategy that seems to resonate, as stated earlier, with their cultural upbringing (Ngara, 2007; Owuor, 2007).

(4) Metacognitive assessment of often used and contextualized science modeled learning strategies

The students seemed to become metacognitive about the appropriateness of the science learning strategies they often used, and those modeled in the contextualized science unit. This can be discerned from views conveyed in interview responses regarding their experience of learning strategies modeled in the science unit. The following views were implied in responses to the after in-class interview questions: no longer cramming; planned reading and understanding; critical of prevailing practice of reading for exams; awareness of personal modes of learning; awareness of embedded science in home environment; and critical of previous separation of classroom and embedded science in home environment. Similarly the following were discerned from the 1-year later interview responses: need based group consultation; consultative group on mutual/shared interests (e.g., career, project work); convert to group work; learned to be open and ask when challenged; improved performance; and appreciation of what a group can offer.

As illustrated by the two excerpts below, the students who were interviewed self-declared that cramming (rote learning) was a necessary but not preferred strategy they often employed to pass exams whenever they could not understand the science content. This, in a way, meant that the students became aware (*metacognitive*) of unfruitful ways of learning science, although they still accepted the strategies as long as the existing exam culture prevailed. Also, it might be suggestive of the immense influence external examinations (which every student in Kenya has to take at the end of his/her high school education) has on these students, forcing them to take refuge in cramming as a *security* or safety measure against failure. This can be a key influence on student disposition towards *content-centered* learning (Murphy, 1968) which is usually a consequence of exam driven teaching and learning. This may sometimes manifest in learning strategies, intimated by some students, such as Monica's perception of understanding implied in her claim of reading over several times the science content she does not understand; Fatima's revelation that she crams for exams only and forgets the information after:

> I have come to realize that I hate cramming . . . and now I prefer actually reading a month before the exam to find out how it applies to our real life as I just saw in the Jua Kali. Otherwise, if I don't understand, I just cram it and then I do the exam and forget about it . . . [But] I prefer to understand something rather than cram and forget.

These sentiments are echoed by Mary who conveys that after the exam she does forget about it. The impression we get is that Mary is driven by exams and studies for the exam. Thus she says:

> People just learn science in class and in the lab and just do exams and go home. They don't actually see these things in real life as we saw them in Jua Kali. The teacher will never bring a *Jiko(charcoal stove)* to class and ask how science is applied. You just hear clay is a good insulator. You just cram, do the exam and you go. But then you never really think of it in the home that this *Jiko* uses clay because it is an insulator.

Interestingly, Enid seems to have always known that concept mapping would work for her, which she never employed until after the Jua Kali experience, and which she claims challenged her to turn to this strategy: "When I cram I forget it after the exam. That is why after the Jua Kali I got challenged to turn to my [concept] mapping skills to help me visualize connections to the real world." On the other hand, Monica seems to be metacognitive through the awareness of her learning when she says: "I can't just read something once and I understand it. I cram but after repetitive reading I understand it and I can even use the same words from the book word for word."

Although reading and re-reading several times over is what most people do, and inevitably part of reflective/critical reading, in Monica's case it seemed to mean cramming (learning-by-*rote*) as revealed in her response in the interview excerpt above. She considers repetitive reading and the ability to reproduce the exact text in a book as understanding. However, what is revealed in the statements provided by Fatima, Mary, Joyce, Monica, and Enid is a circumstance dictated by a survival strategy, to pass exams. It has already been pointed out that the nature of instruction in Kenyan classrooms is dominated by modeling a knowledge-based, individualistic exam-driven culture. This appears to be due to the decontextualized nature of the school science curriculum and instruction for which the students see no merit. But after the integrated classroom-Jua Kali science unit experience, students seem to more easily understand the benefit of connecting science to the real world.

One year later, the students who participated in the study appear to realize that well-understood science might implicate good grades in exams. However, as illustrated in their earlier sentiments about the current curriculum/syllabus, in their view, it still does not allow them much opportunity to learn science contextually or through socially mediated strategies. Specifically, these views were expressed in response to a question that asked the students to indicate how often they worked as a group as they did during the 9-week curriculum unit, and if they still found it a helpful learning strategy 1 year later. In response to the question, Mary said: "Right now we have a bigger workload, though we still consult each other when we come across a certain aspect of science that we think we can now discuss.'' Monica seemed to indicate that future career aspirations tended to determine the nature of the grouping: ''Our goal to do sciences in the future has made us committed to our group and made us productive.'' And, Enid credits the groups learning strategy with her improved performance: ''I've been able to broaden my perspective of things more than the kind of strategies I have for my studies. I've been able to interact with these sisters and I've seen a drastic improvement in my grades.'' Moreover, Fatima declares: ''I used not to be a group person; . . . But now, being in a group is very nice and it's very helpful and I'm thankful to each and every one of these sisters.''

One year later, the same students express how they have come to value working with peers, consulting with them, and appreciating the richness of this new alternative learning strategy. It is compelling to see Fatima's acknowledgement in the above excerpt of the gains of socially mediated learning. This case speaks to the fact that it is not easy for students to appreciate the effectiveness of alternative learning strategies until they personally experience them or unless situations are created for them to experience the different strategies.

Joyce sees frequent consultation as contributing to her learning while Enid now admits that working in her group has broadened her perspective of understanding science and contributed to her grade improvement. In the same vein, Mary and Monica, while still intimating the pressure from the overloaded curriculum, still appreciate the usefulness of peer group consultation. What is clear from these students is a desire to understand and not just to cram for the sake of the exams. One year ago, based on what has already been reported about this group and undesirable learning strategies, they incorporated consultation in their language, a term that was never in their vocabulary. Instead, it was, ''they cram it and forget about it after the exam.'' But now, embedded in the excerpts highlighted above, is the desire for understanding; a change in the culture towards socially mediated learning, which according to contextual learning perspective is organized in ways that allow students opportunities to engage in real-world problem solving activities (Karweit, 1993). This was self-declared as having enhanced learning of a new and fruitful learning strategy, which they claimed improved their performance.

Conclusions and Implications

The students who participated in the study seemed to experience multiple tensions that exist between the pedagogical practices they were exposed to and their perceptions of understanding science through their own modes of learning evoked by the study's learning activities/experiences. These modes of learning are in many respects idiosyncratic. The students' voices contained perceptions of learning conveyed in the illustrative interview excerpts above, which is consistent with our previously stated belief that classroom knowledge should have relevance to real-world contexts. Nonetheless, the students in this study had the purpose of passing the exams. These high stakes exams are similar to the exams for which the teacher in Upadhyay's (2005a) study prepared her students. Similar to the revelations by some of the students in this study, the teacher as reported by Upadhyay wanted to empower her students so they could continue with schooling. In the same vein, the students in this study self formed study groups based on their future aspirations. It is interesting to note in Upadhyay's study that whereas localizing teaching is empowering, ''using students' lived experiences is a risky act'' (p. 343) for it involves negotiation. This points to the affirmation of the potential benefits for understanding science knowledge in the local environment (Gay, 2002; Hull, 1993;

Karweit, 1993). Hence, this should start to provoke and sustain the ongoing debate about relevance in science curriculum in Kenya and elsewhere. For Kenya in particular, there should be questions about reforming both the school curriculum and pedagogy in tune with students' peculiar and idiosyncratic ways of learning and knowing, which they might have developed in homes and through other lived experiences that they can use or be leveraged in formal education (Zimmerman, 2012). Furthermore, the reforms should deliberately involve making curricular and instructional links to students' local contexts, demonstrated in literature and as reported by Upadhyay (2005a) about using students' lived experiences to teach science. This in a way can evoke students' funds of knowledge that according to Upadhyay (2005a) has accumulated through their lived experience, and is ultimately what they bring to the classroom. In the current study, this is what is perceived by the students to mediate meaningful learning.

As demonstrated from the exemplar group, the students who were interviewed expressed disposition for context-centered, social-centered, and value-centered learning of science when opportunities that evoked and allowed them to engage these potentials or what Zimmerman (2012) refers to as competences were offered in the classroom-Jua Kali integrated learning experiences. Furthermore, they became more reflective of their own learning processes; celebratory of their personal benefits of consulting their trusted peers; sensitive to and/or oriented towards learning from real life contexts. All this seems to elaborate what Zimmerman (2012) has noted as engagement of competences that the students engaged in out of school settings where we believe they are comfortable. For example, the students in the current study engaged mostly observational inquiry competence, when they sought explanations from the Jua Kali artisan and peers. The other competences had either been engaged in homes or other non-school settings. There is a greater possibility that their experience of participating in the classroom-Jua Kali science unit allowed them the opportunity to engage in science learning from and embedded in their local context. Again according to Zimmerman (2012), this in a way was about accessing new science learning in school and out of school contexts.

The implication of all the findings is to pause and rethink the curriculum and pedagogy. The Kenyan education and similar ones elsewhere need a way forward in meaningfully reforming the education system with the views expressed by the students represented in this article. Hopefully, if the views of those who will succeed in the current system are influenced by projects such as the one reported here, then when they attain positions of decision-making with regard to how best to realize visions espoused in national and international organizations' policies, such as science for all and increased scientific literacy. For Kenya, this could be how the national vision of becoming an industrialized nation (The 1997–2010 Republic of Kenya Master Plan on Education and Training, MPET, 1998) is realized.

The study's findings have implications on research. What is presented here are the views of a small group of students. Nonetheless, the insights generated can inform the framing of a longitudinal study to follow the students into their college and university life to establish the extent to which they still use local contexts to learn science, and the challenges they might be facing using this approach in higher learning. It would be important to study the lives of those from this group who end up in Jua Kali, and the impact they might have on the quality of Jua Kali products and innovations.

This article strongly advocates a contextual model approach that recognizes the great potential in understanding and applying science embedded in students' local environment. The model is borne out of the demonstrated realization by student participants in the study that a better understanding of science begins with seeing its relevance and meaningfulness in local contexts and permitting opportunities for them to engage inherent cultural modes of learning (e.g., groups).

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