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Instrument for Assessing Disposition for Contextual Learning of Science of Students in East Africa

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Abstract

Attempts to make classroom science relevant to the real worlds of students can be enhanced by understanding their ways of learning and knowing. This study, which investigated East African (EA) students' ways of knowing in science discourses, discusses the development, validation, and application of an instrument to assess EA students' disposition for contextual learning of science. The Instrument for Assessing Disposition for Contextual Learning of Science (I-ADCLOS) is intended to assist teachers and students to assess their degree of disposition for contextual teaching and learning of science. Exploratory factor analysis of student responses to a 36-item questionnaire developed from theory yielded a validated 31-item I-ADCLOS comprising three dimensions and six subdimensions: Personal Awareness of Influences on Learning Science and Limitations of Traditional Knowledge (PA_ILS_LTK); Attitudes Towards Science Learning in Local Contexts and Nature of Traditional Knowing (AT_SLiLC_NoTK); and Orientation Towards Collateral and Personal Learning Strategies (OTC_PLS). These dimensions were further explored and determined to each bear two subdimensions—PA_ILS_LTK: (a) independence of science learning from cultural influences and (b) metacognitive learning; AT_SLiLC_NoTK (a) instrumentalist–culturalist perspectives and (b) exam-centered, textbook/teacher reliant learning; and OTC_PLS (a) personal awareness of successful learning strategies and other ways of knowing and (b) privileging science and learning by rote.

Keywords

education, social sciences, curriculum, science, math and technology, educational research, teaching

Introduction

In East Africa, and particularly Kenya, an informal sector known as "Jua Kali" has turned into the largest employer of elementary and high school graduates (Maundu, 1997; McLeanand & Kamau, 1999). Jua Kali is a small-scale manufacturing and technology-based service sector (UNESCO, 1997). The name is derived from the conditions (scorching sun) under which the artisans who manufacture equipment and provide related services to other small-scale producers operate. Over the years, Jua Kali artisans have been grappling with the challenge of developing more efficient, environmentally appropriate products that utilize locally available resources that would otherwise go to waste.

Although there are numerous products produced within the Jua Kali sector including charcoal stoves, kerosene lamps, and chicken brooders, all of which are prevalent household items ubiquitous in everyday Kenyan culture, classroom teaching of science rarely makes links to scientific phenomenon richness of these local production activities and products. Given that Jua Kali has become the most direct pathway for securing employment by high school graduates compared with securing employment in the diminishing public sector, we see it as an important reason to rethink high school education programs, especially science education the majority of students receive. It is also a common rhetoric in the Kenyan media and public policy documents to transform this sector into a competitive industrial sector (e.g., Master Plan on Education and Training [MPET]; Republic of Kenya, 1998). This vision of industrialization appears unlikely to be realized without understanding how to connect classroom science to the real world of Jua Kali.

It is the view in this paper that classroom knowledge should have relevance to real-world contexts. Moreover, industrialization will mean production of goods that are

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competitive both locally in Kenya and elsewhere. It means that those who join Jua Kali need to have the relevant scientific and technological knowledge and skills to transform the sector. Hence, there is a need to refocus science teaching by using local contexts or materials to deepen students' understanding of science and its relevance to their local environment. Yet there is no strong curriculum link between activities in the Jua Kali, which have come to characterize the common sociocultural environment of many young Kenyans, their school science (classroom knowledge), and their culturally shaped ways of knowing (Cobern & Aikenhead, 1998; Falk, 2001). However, any attempt to link classroom science to the real world of Jua Kali activities cannot be effectively developed if there is no understanding of students' ways of learning and knowing, implied in their degree of disposition to contextualized learning, which according to Baker, Clay, and Fox (1996) are shaped by their sociocultural environment.

Ways of knowing is a term that has no clear definition. In this paper, we develop an operational definition that implies the processes the individuals go through to make meaning of the world and its content. Although on the macro level, science is referred to as a way of knowing, we are interested in what these students do to claim knowledge of the world including science. We consider ways of knowing to include the following: seeking understanding and meaning; seeking relevance (relating to personal surrounding); observing others and self (apprenticeship); analogizing/metaphorizing (Lagoke, Jegede, & Oyebangi, 1997; Nashon, 2003, 2004; Pittman, 1999); anthropomorphizing (Nashon, 2003, 2004; Watts and Bentley, 1994); reading about; questioning; answering questions, asking and answering self-questions (metacognitive; Anderson & Nashon, 2007; Gunstone, 1994; Nashon & Anderson, 2004), teaching others, creating algorithmic songs/poems; hearing from significant others and discussing with peers/elders/authorities; doing; imaging; creating/modeling (Gilbert & Boulter, 2000); and symbolizing.

To date, there is no reported research that considers East African high school students' ways of learning and knowing and related worldviews in the context of science activities that integrate classroom science and the science imbedded in the Jua Kali activities (real world).

In this study, we hold several key assumptions: (a) understanding how students see the world and harnessing this understanding can enable the development of better science learning experiences, (b) examining Kenyan students' ways of learning and knowing can enlighten our current understandings of how people make meaning of the world, (c) recognizing the relationship between classroom science and the science imbedded in the Jua Kali (real world) production activities is a key step toward the attempt to revolutionizing this sector to the benefit of Kenya, and (d) understanding Kenyan students' ways of learning and knowing will inform education programs through which the majority of Jua Kali artisans are prepared.

Using Local Contexts to Teach and Learn Science

Although this can be interpreted differently, in this study we use Hull's (1993) contextual learning theory as a basis for understanding and interpreting learning activities that would be considered as contextualized learning of science in particular (Nashon & Anderson, 2013). According to Hull, contextual learning involves the mind in seeking meaning in a context as well as relationships that make sense and resonate with one's sociocultural background. Thus, contextual teaching and learning of science means using local contexts to explain scientific concepts or phenomena by showing how the concepts can be applied in solving local everyday problems. In some cases, this is presented as making science relevant to students. There are two commonly applied perspectives to contextual learning of science and are defined by the point in the teaching learning processes when links are made to the learners' local context. Although both approaches aim to fulfill the desire to make students see the links between classroom science and their everyday life, the two approaches are subtly distinct (Bennett, 2003). According to Bennett (2003), the distinction is at the point where the links are made. In the context-based case, the links are made at the beginning of the topic and used as a starting point to introduce and develop scientific ideas, whereas in the relevant science case, the scientific ideas are introduced first and then links are made. In this paper, we use contextualized science to mean both context-based and relevant science. We adopt this loose understanding to be in consonant with the constant cry for making science education relevant and meaningful (Knamiller, 1984; Tsuma, 1998; Yoloye, 1986). As demonstrated in the literature, contextualizing science teaching and learning promotes active engagement of students with respect to interest and motivation (Campbell, Lazonby, Nicholson, Ramsden, & Waddington, 1994; Fensham, 1988; Hofstein, Aikenhead, & Riquarts, 1988). Originally meant for nonscience students, contextualized science has been used to make a case for addressing the concern of many students in high school who are dropping out of science courses early and, by extension, very few of them are getting into science-related postsecondary programs. These concerns indeed have not spared East Africa and, in particular, Kenya.

The Kenyan Context

Despite numerous attempts to reform education in East Africa and, in particular, Kenya, considering that the question of relevance has always been discussed as part of the reform agenda, careful analysis of the state of education, and especially science education, tells that attaining relevance is like a mirage (Knamiller, 1984; Yoloye, 1986). Over the years, there have been reform-driven commissions of inquiry into matters of education and its relevance in Kenya (Gachathi, 1976; Kamunge, 1988; Koech, 2000; Mackay, 1981; Ominde, 1964a, 1964b) and all have at best elicited the unending national debate on the question of relevance in terms of the role of science and technology in national development.

Despite the major structural changes in Kenya's education system over the years, with the question of relevance characterizing the rhetoric for change, there has never been much effective shift from *traditional* Western-modeled curriculum and pedagogy, especially in science education. The system is still overly exam driven and teacher centered, with colonial as well as foreign-leaning science curriculum and pedagogy. This apparent static nature of curriculum and pedagogy is due in part to colonial hangover and influence whereby for a long time foreign experts who had limited knowledge of the local Kenyan context dominated high school curriculum development and implementation (Sifuna & Otiende, 2006). Also, those Kenyans positioned to influence change were often trained abroad, or trained locally by foreign experts, and thus, they lacked the skills needed to reform curriculum and pedagogy to reflect the relevance of science to the local context (Sifuna & Otiende, 2006). In addition, they often borrowed from foreign instructional models not suited for the Kenyan learner. This has made teachers less receptive to innovative pedagogies. Instead, they focus more on getting students to pass exams. The need to make science relevant to the students is regarded as superfluous to examination performance and, at best, perpetuates the traditional culture where science is presented as an encapsulated system that has no relevance to the students in terms of their local contexts and everyday lives (Tsuma, 1998).

Any attempts to integrate into curriculum authentic science learning activities in contexts such as Jua Kali are seen as unnecessary distractions. But for most Kenyans, the question of relevance is very important as eloquently expressed by Tsuma (1998): "no Nation can develop in any sense of the term, with a population which has not received a thorough and relevant education" (p. i). And, despite the local setting's richness in scientific phenomena that can be readily mediated through curriculum, Kenyan science teachers rarely exploit this potential to mediate student learning. Hence, there is a need for Kenyan teachers to change the way science curriculum and pedagogy are reformed as a means to making science more relevant and meaningful to Kenyan learners.

The Nature of Science Curriculum and Instruction

The Kenyan education system operates in 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. 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. KCSE enables the students to join universities, middle level colleges, or polytechnics. One of the requirements is to pass in at least one of the main science subjects (physics, chemistry, and biology) and mathematics to be graded or receive a certificate, which in Kenya is the basis for consideration for entry into postsecondary programs.

The national language of Kenya is Kiswahili. However, all examinations are written in English, as it is both the official language and medium of instruction in Kenyan schools. Use of English as a medium of instruction in Kenya starts from Standard (grade) 4 up to university, although prior to Standard 4, it is taught only as a subject. Selection in a high school and university in Kenya depends on a student's performance in 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 has performed on KCPE exam.

Prior to sitting these national examinations (KCPE and KCSE), the students are subjected to rigorous testing and mock exams. In fact, throughout the years preceding the national examinations, testing is routine, where teaching and testing are driven by past examination content.

Faced with the task of helping the students to do well in these exams, the teachers adopt extreme teacher-centered approaches where note giving, *hunch giving* about possible areas on the exam, and drilling for exams characterize instructions. In a very subtle way, teacher performance or productivity is determined by how many students pass in their respective subjects or courses. This situation makes teachers less receptive to innovative pedagogies or any attempt to place the responsibility for learning on the students, where the teachers become facilitators of student learning as opposed to transmitters of knowledge.

An implicit and prevailing attitude among high school teachers is that they do not need new teaching methodologies, and the need to make 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, and the visits to authentic science learning environments are unnecessary distractions. The practice in most Kenyan classrooms is that teachers subject the students to only exam-content-laden lectures. The limited number of university places for which high school graduates compete exacerbates this.

Currently, the Kenyan curriculum is still modeled on an outdated, decontextualized curriculum that is irrelevant to the majority of the students. Also, it lacks relevance in terms of connections to work places—the Jua Kali, where 75% of high school graduates get employed. Furthermore, there is lack of real mechanisms to help facilitate Kenyan industrialization via effective links to school curriculum, in particular, science education. Confounding this problem is the fact that there is no reported research that considers Kenyan high school students' dispositions for learning that integrates classroom science and the science imbedded in activities in the real world of Jua Kali. Thus, developing an instrument to assess students' disposition for contextual learning of science is a first step in the attempt to understand how to connect classroom science to events in students' local environment.

A Review of Personality Assessment Instruments in Science Education

A number of instruments that assess students' personality constructs associated with science are available, understanding of which informed the general framing and construction of the items on Instrument for Assessing Disposition for Contextual Learning of Science (I-ADCLOS). A variety of standardized instruments are available that can be used to assess different personality behaviors and characteristics. Some of the instruments are specific to science, while others are general but relevant to science.

Based on assessment type, these standardized instruments can be grouped into five major categories: interviews, point scale, multiple choice, short and extended response, and drawing. Examples of instruments falling under each category are briefly outlined in the next sections.

Interview type of instruments. This category includes instruments such as Views of Nature of Science Questionnaire (VNOS-D) and Views of Scientific Inquiry, Primary School Version (VOSI-P).

VNOS-D is a seven-open-ended-question instrument that assesses students' views about the empirical, tentative, inferential, creative, and imaginative nature of science, as well as the distinction between observation and inference; and VOSI-P is a five-open-ended-item questionnaire that is used to elicit details of learners' ideas of what scientists do in the production of valid scientific knowledge.

Point scale/Likert-type scale instruments. Commonly available instruments in this category include: Scientific Attitude Inventory: A revision (SAI II), Modified Attitudes Towards Science Inventory (mATSI), Relevance of Science Education (ROSE) Student Questionnaire, Views About Science Survey (VASS), Asian Students Attitudes Towards Science (ASATS) class survey, Changes in Attitudes About the Relevance of Science (CARS), Thinking About Science Survey Instrument (TSSI), Children's Science Curiosity Scale (CSCS), Science Opinion Survey (SOS), Wareing Attitudes Toward Science Protocol (WASP), Revised Women in Science Scale (WISS-R), Exploring Physics Confidence Survey (EPCS), Revised Simpson–Troost Attitude Questionnaire (STAQ-R), Science Motivation Questionnaire (SMQ), Environmental Values–Short Form (EV-SF), Self-Efficacy and Metacognition Learning Inventory–Science (SEMLI-S), Attitude Toward Science in School Assessment (ATSSA), Critical Thinking in Everyday Life (CTIEL), Chemistry Attitude and Experience Questionnaire (CAEQ), College Biology Self-Efficacy Instrument (CBSEI), Test of Mathematics-Related Attitudes (TOMRA), and Self-Concept and Competence Scale in Physics (SCACSIP).

SAI II instrument comprises 40 items on a 5-point Likert-type scale and assesses students' interest in science, their attitude toward science, their views of scientists, and their desire to become scientists; mATSI comprises 25 items on a 5-point Likert-type scale and measures students' attitudes toward science related to such factors as students' perceptions of the science teachers, anxiety toward science, values of science in society, self-concept toward science, and desire to do science activities.

The ROSE instrument comprises items in various scales and assesses children's interest in, attitude toward, and experiences in science and technology; VASS is a 30-item on a 5-point scale instrument and probes personal beliefs about the nature of science within three scientific dimensions (structure, methodology, and validity of science) and learning science within three cognitive dimensions (learner ability, reflective thinking, and personal relevance of science); ASATS class survey uses 30 items on a 5-point Likert-type scale and assesses three science attitude constructs (science enjoyment, science confidence, and importance of science as related to science class experiences) based on Asian school culture; CARS was developed to measure the change of science-related attitudes over time among students and the effect of similar curricular on the attitudes of different classes.

TSSI instrument is a 30-item, 5-point Likert-type scale and assesses sociocultural resistance to and support for science that can be used in efforts to quantitatively document the presence or absence of significant cultural factors that contribute to resistance or affirmation of science; the CSCS instrument uses 5-point scale items to measure elementary school children's attitudes toward science in a learning context; the SOS instrument comprises 30 items on a 5-point Likert-type scale and assesses current interest and attitudes in science activities at school; the Test Of Science-Related Attitudes (TOSRA) instrument comprises 70 items on a 5-point scale and assesses science-related attitudes along seven dimensions, namely, social implications of science, normality of scientists, attitudes toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science

WASP is a 50-item, 5-point Likert-type scale instrument that measures the relationship between various aspects of class achievement (students' self-reported grades, number of tests, internal structure of the course, degree of rewards, degree of stress, gender) and students' attitudes toward science; WISS-R is a revised 14-item, 6-point Likert-type scale version of the original tool, WISS instrument, that assesses attitudes of adolescent girls and boys toward women in science. It uses no option for a neutral response; the EPCS instrument comprises 6 closed-ended questions on a 9-point Likert-type scale and evaluates physics extracurricular program, with a focus on female students.

STAQ-R is a 22-item, 5-point Likert-type scale of the revised version of the original tool Simpson–Troost Attitude Questionnaire (STQ), which evaluates factors influencing commitment to and learning of science among adolescent students; the SMQ instrument has 30 items on a 5-point Likert-type scale, measuring the domains of engagement and attitude; the Inventory of School Motivation (ISM) instrument contains 68 items on a 3-point scale, 44 items on a 4-point scale, and 20 items on a 5-point scales, measuring high school students in the domains of engagement, attitude, competence, and career, as well as evaluates the reasons for students to abandon science, engineering, and medical (SEM) pipeline while others choose to continue; the Epistemological Views Towards Science (EVTS) instrument contains 35 items on a 5-point Likert-type scale, measuring high school students in the domains of engagement and career as well as evaluating students' epistemological views toward science; the EV-SF instrument contains 31 questions on a 5-point Likert-type scale and assesses people's attitudes toward their environment; the SEMLI-S instrument contains 30 items on a 5-point Likert-type scale and assesses students' metacognition, self-efficacy, and constructivist science learning processes in the domains of knowledge, skills (critical thinking, communication), and motivation (attitude, self-efficacy, values)

ATSSA instrument contains 14 items on a 5-point Likert-type scale and assesses middle and whigh school students' attitude toward science; the CTIEL tool has 20 items on a 5-point Likert-type scale that assesses youth's critical thinking ability by examining constructs of reasoning, enquiry, analysis/information processing, and flexibility; the CAEQ instrument has 76 items on a 5-point Likert-type scale and measures 1st-year university chemistry students' attitude toward chemistry, chemistry self-efficacy, and learning experiences; CBSEI contains 15 items on 5-point Likert-type scale, measuring undergraduate students in the domain of competence; the TOMRA instrument contains items on a 5-point Likert-type scale for measuring the attitude of middle school students toward math class; and SCACSIP contains three items as part of a questionnaire on a 5-point Likert-type scale assessing students' interest in physics in general, in relation to physics course they have at present, and in relation to other science and nonscience courses.

Multiple-choice instruments. Instruments under this category include Children's Environmental Attitudes and Social Knowledge Scale (CHEAKS), Epistemological Beliefs Assessment for Physics Science (EBAPS), National Assessment of Educational Progress (NAEP) Science Assessment Instrument, and Program for International Student Assessment (PISA).

CHEAKS contains 36 items on a 5-point scale addressing attitude, and 30 multiple-choice questions addressing knowledge that measure children's global attitudes and knowledge about environmental issues, such as animals, energy, pollution, recycling, water, and general issues; the EBAPS instrument contains 30 items on a 5-point scale and multiple-choice items that measure students' views about nature of knowledge and learning in the physical sciences; the NAEP instrument contains multiple-choice questions, short constructed response questions, and extended constructed response questions that evaluate students' knowledge of three fields of science (i.e., earth, physical, and life); and the PISA instrument has several multiple-choice items on various 4-point scales that assess how well students can apply the scientific knowledge and skills they have learned at school to real-life challenges.

Short and extended response instruments. Instruments under this category include VNOS-D and NAEP Science Assessment Instrument. The NAEP and VNOS-D instruments appear in more than one category, that is, interview and short and extended response.

Drawing instruments. Draw-a-Scientist Test (DAST) particularly assesses children's conceptual images of a scientist. It consists of open-ended projective items on a 7-point scale based on the presence of personal characteristics (e.g., lab coat, eye glasses, facial hair, pencils/pens in pocket, unkempt appearance), symbols of research (e.g., test tubes, flasks, microscope, Bunsen burner, experimental animals), symbols of knowledge (e.g., books, filing cabinets), signs of technology (e.g., solutions in glassware, machines), drawings depicting men/women, drawings depicting racial/ethnic group of scientists, and so on.

NAEP and VNOS-D instruments appear in more than one category. While the instruments reviewed attempt to measure or assess a wide range of personality constructs in general, there appears to be a lack of instruments assessing students' disposition for learning science in local contexts. Hence, the development of I-ADCLOS attempts to contribute to a growing stock of instruments to be available to teachers and students to gauge their level of disposition for this way of learning science.

Objectives

This article reports on the (a) development and validation processes of a questionnaire instrument, I-ADCLOS, and (b) insights into the influences that underlay students' decisions or orientations as derived from the questionnaire's quantitative data through a process of factor and follow-up interview analyses that resulted in emergent factors and subfactors, through validating interview themes after the participating students experienced an integrated classroom–Jua Kali science discourse.

Importance of I-ADCLOS

I-ADCLOS can help teachers gain insight into their students' prior disposition toward contextual learning of science. The instrument development and validation process was part of a research that investigated (a) students' potential disposition to engage and learn science in integrated classroom–Jua Kali–based activities, and (b) students' ability to link classroom science to the science imbedded in the Jua Kali products and production activities. Having knowledge of the students' potential dispositions is important in planning contextualized science activities in terms of their interest, learning culture, and learning strategies. For the teachers, such information from the students should be useful in creating science curricular units that better connect classroom science to the students' social cultural environment.

Theoretical Framework and Literature Review

This paper draws on sociocultural theories of knowledge construction (Vygotsky, 1978) to develop and use a questionnaire instrument to assess and interpret students' potential dispositions to contextualized science learning. The interpretation process was aimed at elucidating their ways of learning and knowing through a validation process that involved factor analysis of questionnaire data prior to and interview data after experiencing an integrated classroom–Jua Kali science discourse. Sociocultural perspectives place emphasis on the interdependence of social and individual processes of knowledge construction, especially social sources of individual growth and semiotic (signs and symbols, including language) mediation in human development (John-Steiner & Mahn, 1996). Also, given that learning is an ongoing process, we consider the students' learning strategies as being shaped by the culture in which they learn.

Consistent with these theories, learning is seen as occurring holistically and not in isolated contexts (Ausubel, 1963) 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; Nashon & Anderson, 2004), attitudes, and personal background (Guerts, 2002; King, Chipman, & Cruz-Janzen, 1994; Lave & Wenger, 1991). Furthermore, as Lave and Wenger (1991) stipulated, learning is situated in some community/culture, which is typically defined by sociopolitical environment as well as historical context. In the case of Kenya, these are critical influences on teachers' practices. As earlier indicated, for Kenya, curriculum is modeled on the outdated Western content and formats. This is a historical fact as it is in part a colonial legacy as well as political with regard to policy making. This should be no surprise as it is often a fact for decision makers to hang on to or invoke a system in which they themselves succeeded as learners. Furthermore, it is considered in this article that learners' conceptions of science have direct impact on the ways in which they learn (Hodson, 1998). Also, the learners' worldviews are the key to influencing their perceptions, interpretations of experience, and ultimately the conceptions of their reality (Hodson, 1998).

The sociocultural identities of individuals and the groups to which they belong determine the cultural tools that they use to make sense of the world (Anderson, 2003; Bell, Lederman, & Abd-El-Khalik, 2000; Nashon, 2003, 2004). Hence, I-ADCLOS is meant to provide science teachers with insight into students' degree of disposition to contextual learning of science so that they are able to develop contextualized learning experiences that can influence the students to see the need for this approach to science learning.

The aforementioned sociocultural frame elaborated was very important in developing questionnaire items to elicit students' individual dispositions toward contextual learning of science. The dispositions are shaped by the sociocultural milieu in which the students live. As local contexts are socially created and regulated by the culture in which the students reside, we see a sociocultural framework to be appropriate in the development and interpretation of questionnaire items and student responses, respectively.

The literature on context-based science teaching and learning is broad, but in this paper we specifically focus on the literature that informed the development of I-ADCLOS, which we themed as attitudes toward Jua Kali (attitudes toward science), science learning culture, nature of science, nature of traditional knowledge and sources of knowing, and ways of knowing beyond science.

A critical review of studies involving context-based science and its effect on students indicates strong evidence that this approach to science has positively influenced students' interest in, attitudes toward, motivation about, and understanding of science (Bennett, Hogarth, & Lubben, 2003; Campbell et al., 2000; Ebenezer & Zoller, 1993). In addition, a literature review on the topic of the indigenous African learners (Asante, 1987; Dei, 2000, 2002; Gitari, 2006; Goduka, 1999; Horton, 1967; Mazama, 1998; Nashon, Anderson, & Wright, 2007; Ngara, 2007; Owuor, 2007; Shizha, 2005; Wright, Nashon, & Anderson, 2007) and consultation with teachers and other scholars who were of continental African backgrounds or had had or had ongoing research or professional development projects in Africa enhanced the content of the questionnaire developed to assess students' dispositions for contextual learning of science. Having the emergent understanding to signpost students' potential for disposition for science learning in their local context (Jua Kali), which in our view has rich potential for science teaching and learning, is very important prior to planning subsequent instructional experiences. Moreover, attitudes that have a strong influence on students' level of disposition toward learning in and from a local context shape *what the students choose to learn, how they learn it, and when to learn it* (Hodson, 1998; Nashon, 2005, Nashon &

Nielsen, 2007). Attitudes may be a product of cultural environment. As Shapiro and Kirby (1998) noted, in the last few years, numerous studies have interpreted science teaching from a cultural perspective (e.g., Costa, 1995; Hawkins & Pea, 1987; Krugly-Smolska, 1995; Shapiro, 1994). Others who have shed light on the influence of culture on student learning include Aikenhead (1996) who describes science learning as border crossing and Jegede (1995) who claims that most non-Western students are collateral learners. But sometimes, the *learning culture* of students is shaped by the way they are assessed, taught, and rewarded. The culture of teaching to the exam could easily promote the culture of learning to the exams.

A study by Scoultler (1998) indicated that examination types (multiple choice, essay) have a direct influence on how students learn with constructed perception that multiple-choice examinations require shallow or surface thinking while essays require deep thinking. By extension, examinations and the nature of items on them inevitably influence students' *learning culture*. It is important to know students' learning culture to design strategies that are attractive to them and not appear to threaten their ability to pass the exams.

The learning culture in which students operate and embrace would inevitably influence their *views of the nature of science* (Lederman, 1992; Nott & Wellington, 1993). It is important to elicit these views because how the students view science will necessarily influence their attitudes and learning culture. Similar to the nature of science, students bring to science discourses views that are influenced by traditional knowledge, which they grow up developing. It is well documented in the literature that non-Western cultures do hold multiple frameworks alongside scientific reasoning (Aikenhead & Jegede, 1999; Cobern & Aikenhead, 1998; Horton, 1967; Jegede, 1995, 1996). This is very important especially when attempting to influence teaching of science through local contexts. This awareness is important as it can reveal what frameworks science is competing with, and it is possible that local contexts will inevitably evoke culturally entrenched views that need careful handling (Cobern & Aikenhead, 1998).

What students possess as knowledge comes from a diversity of sources. Sources tend to be the authorities that students invoke in defense of their views/understandings of the world. Typically, in traditional science classrooms, the teacher, textbook, and significant others are sources most commonly referenced during science discourses. It has been widely reported and acknowledged in the literature that students come to science classrooms with already constructed views of the world (Driver, 1983; Hodson, 1998). Some of the views are inconsistent with scientific reasoning. Nonetheless, this does not invalidate other *ways of knowing beyond science*. This is the reason why constructivist approaches to teaching recommend eliciting students' prior understandings including how they came to know what they know (Driver, 1983, Driver & Erickson, 1983; Hodson, 1998).

Ways of knowing beyond science have been widely discussed including Horton's (1967) seminal work on African knowing complemented by Gitari's (2006) work on health and healing, in which she discusses revelations from her study of a rural Kenyan community's knowledge of health and healing that showed personal learning tools, relational learning tools, genres of moral obligation, and genres of knowledge guarding as unique and indigenous ways of learning and knowing.

This literature synthesis provided an understanding that influenced the construction of items on the questionnaire as well as provided an interpretive lens consistent with the sociocultural framework for the emergent dimensions and subdimensions following factor analysis of students' questionnaire responses and follow-up interviews.

Method

This study used both quantitative and qualitative approaches to the development and validation of a 36-item instrument or questionnaire for assessing students' disposition for contextual learning of science (I-ADCLOS; see Table 1a). The construction of items was guided by theoretical insights from the literature synthesized earlier with regard to Attitudes Towards Science in Jua Kali (Attitudes Towards Learning Science in Local Contexts [AT_SJK]; 7 items), Science Learning Culture (SLC; 11 items), Nature of Traditional Knowledge and Ways of Knowing Beyond Science (NOT_WKBS; 9 items), Nature of Science (NOS; 4 items), and Sources of Knowing (SK; 5 items). As a first tier, the instrument was piloted with 36 students and quantitative methods including Cronbach's alpha reliability tests and exploratory factor analyses were used to inspect, refine, and validate the instrument, I-ADCLOS.

The data, initially obtained from 36 students purposely selected from the participating schools and representative of the diverse cultural background of the student population that participated in the in the study, were first inspected. The students with incomplete or no data were excluded resulting in 29 valid cases (Table 1c). Negatively stated items were reverse coded. The inspection of the items' content and their effect on the Cronbach's alpha reliability led to the deletion of some items. In other words, apart from the content being inconsistent with the scale, the deletion of the particular items did not affect the Cronbach's alpha reliability (Table 1d) of the instrument.

However, due to the small sample size of the pilot, the initial factors were considered tentative as some of the items loaded on more than one factor. But these acted as guidance to further analysis. The refined instrument was administered to a further 261 Kenyan high school students. Exploratory factor analysis tests to determine the dimensions (factors) and subdimensions (subfactors) were carried out. Also Cronbach's alpha reliabilities for each factor were inspected to ensure that the items were reliably assessing the content of the dimension. The item

Table 1a. Initial 36-Item I-ADCLOS.

No.	Question	Scale	Circle one number
1	No science is involved in making the Jua Kali products	Strongly disagree	1 2 3 4 5 Strongly agree
2	There can be no learning of science in the Jua Kali environment	Strongly disagree	1 2 3 4 5 Strongly agree
3	I find Jua Kali sheds in places where I can see the science I have learned in school	Strongly disagree	1 2 3 4 5 Strongly agree
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	Strongly disagree	1 2 3 4 5 Strongly agree
5	The science we learn from school has no relevance to Jua Kali	Strongly disagree	1 2 3 4 5 Strongly agree
6	Science can only be learned in the classroom	Strongly disagree	1 2 3 4 5 Strongly agree
7	“Jua Kali” sheds cannot play a role in my understanding of science	Strongly disagree	1 2 3 4 5 Strongly agree
8	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	Strongly disagree	1 2 3 4 5 Strongly agree
9	Jua Kali activities have no connection with science	Strongly disagree	1 2 3 4 5 Strongly agree
10	It is not helpful to learn things that will not be tested on the exam	Strongly disagree	1 2 3 4 5 Strongly agree
11	Science activities including Jua Kali are only useful if they can help me in passing exams	Strongly disagree	1 2 3 4 5 Strongly agree
12	My knowledge of science is developed through discussions with my classmates	Strongly disagree	1 2 3 4 5 Strongly agree
13	Working together in groups helps me learn science better than working on my own	Strongly disagree	1 2 3 4 5 Strongly agree
14	I understand science better when I share my views with my brothers and sisters (or family)	Strongly disagree	1 2 3 4 5 Strongly agree
15	I am comfortable sharing my knowledge with closest friends	Strongly disagree	1 2 3 4 5 Strongly agree
16	I make sense of the things I learn in school when I read them over several times	Strongly disagree	1 2 3 4 5 Strongly agree
17	All of my knowledge of science comes from my teachers	Strongly disagree	1 2 3 4 5 Strongly agree
18	I memorize science ideas that I suspect will appear on the test or exam	Strongly disagree	1 2 3 4 5 Strongly agree
19	I can never be satisfied with my experimental results until my classmates have the same	Strongly disagree	1 2 3 4 5 Strongly agree
20	I can never be satisfied with my experimental results until my teacher marks it	Strongly disagree	1 2 3 4 5 Strongly agree
21	How I conduct and understand science is not in any way influenced by my religious faith	Strongly disagree	1 2 3 4 5 Strongly agree
22	How I conduct and understand science is not in any way influenced by my culture	Strongly disagree	1 2 3 4 5 Strongly agree
23	There are things in the world around me that cannot ever be explained by science	Strongly disagree	1 2 3 4 5 Strongly agree
24	I accept that there are explanations for natural phenomena that cannot be provided by science	Strongly disagree	1 2 3 4 5 Strongly agree
25	I never question the correctness of our cultural taboos	Strongly disagree	1 2 3 4 5 Strongly agree
26	Science can explain the lightening phenomenon better than our cultural interpretation	Strongly disagree	1 2 3 4 5 Strongly agree
27	I know about the world around me through the stories my elders have told me when I was growing up	Strongly disagree	1 2 3 4 5 Strongly agree
28	The traditional doctor’s knowledge cannot be known by just anyone	Strongly disagree	1 2 3 4 5 Strongly agree
29	The traditional doctor’s knowledge cannot be written down in a book for anyone to understand	Strongly disagree	1 2 3 4 5 Strongly agree
30	My elders have understandings about the world that will only become known to me when I am old like them	Strongly disagree	1 2 3 4 5 Strongly agree
31	There are things the elders tell me to do that have no scientific explanation	Strongly disagree	1 2 3 4 5 Strongly agree
32	The wisdom about the world the elders possess is the unquestionable truth	Strongly disagree	1 2 3 4 5 Strongly agree
33	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	Strongly disagree	1 2 3 4 5 Strongly agree
34	Taboos have no scientific basis	Strongly disagree	1 2 3 4 5 Strongly agree
35	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	Strongly disagree	1 2 3 4 5 Strongly agree
36	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	Strongly disagree	1 2 3 4 5 Strongly agree

Note. Shaded items were deleted after reliability tests and factor analysis. I-ADCLOS = Instrument for Assessing Dispositions for Contextual Learning of Science.

clusters were tested for respective reliabilities. Also each dimensional cluster was factor analyzed to detect any existence of subdimensions and their respective interpretations.

This was followed by harnessing qualitative interview data about students’ ways of learning and knowing with a subsample (n = 24) from the students (n = 261), who had completed the 31-item questionnaire (I-ADCLOS; Table 1b). These interview data served to exemplify the meaning of the factor and subfactors discerned through the quantitative analysis. Tier quantitative analysis of student questionnaire responses complemented by teacher input informed the composition of focus groups for postquestionnaire group interviews regarding their experience with the questionnaire including their individual as well as corporate ways of learning and knowing in science discourses. Although a wide range of topics were probed, this paper used relevant student interview responses as further elucidation of the factors and subfactors emergent from factor analysis.

Table 1b. Validated 31-item I-ADCLOS.

No.	Question	Scale	Circle one number
1	No science is involved in making the Jua Kali products	Strongly disagree	1 2 3 4 5 Strongly agree
2	There can be no learning of science in the Jua Kali environment	Strongly disagree	1 2 3 4 5 Strongly agree
3	I find Jua Kali sheds in places where I can see the science I have learned in school	Strongly disagree	1 2 3 4 5 Strongly agree
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	Strongly Disagree	1 2 3 4 5 Strongly Agree
5	The science we learn from school has no relevance to Jua Kali	Strongly disagree	1 2 3 4 5 Strongly agree
6	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	Strongly disagree	1 2 3 4 5 Strongly agree
7	It is not helpful to learn things that will not be tested on the exam	Strongly disagree	1 2 3 4 5 Strongly agree
8	Science activities including Jua Kali are only useful if they can help me in passing exams	Strongly disagree	1 2 3 4 5 Strongly agree
9	My knowledge of science is developed through discussions with my classmates	Strongly disagree	1 2 3 4 5 Strongly agree
10	Working together in groups helps me learn science better than working on my own	Strongly disagree	1 2 3 4 5 Strongly agree
11	I understand science better when I share my views with my brothers and sisters (or family)	Strongly disagree	1 2 3 4 5 Strongly agree
12	I am comfortable sharing my knowledge with closest friends	Strongly disagree	1 2 3 4 5 Strongly agree
13	I make sense of the things I learn in school when I read them over several times	Strongly disagree	1 2 3 4 5 Strongly agree
14	I memorize science ideas that I suspect will appear on the test or exam	Strongly disagree	1 2 3 4 5 Strongly agree
15	I can never be satisfied with my experimental results until my classmates have the same	Strongly disagree	1 2 3 4 5 Strongly agree
16	I can never be satisfied with my experimental results until my teacher marks it	Strongly disagree	1 2 3 4 5 Strongly agree
17	How I conduct and understand science is not in any way influenced by my religious faith	Strongly disagree	1 2 3 4 5 Strongly agree
18	How I conduct and understand science is not in any way influenced by my culture	Strongly disagree	1 2 3 4 5 Strongly agree
19	There are things in the world around me that cannot ever be explained by science	Strongly disagree	1 2 3 4 5 Strongly agree
20	I accept that there are explanations for natural phenomena that cannot be provided by science	Strongly disagree	1 2 3 4 5 Strongly agree
21	I never question the correctness of our cultural taboos	Strongly disagree	1 2 3 4 5 Strongly agree
22	Science can explain the lightening phenomenon better than our cultural interpretation	Strongly disagree	1 2 3 4 5 Strongly agree
23	The traditional doctor's knowledge cannot be known by just anyone	Strongly disagree	1 2 3 4 5 Strongly agree
24	The traditional doctor's knowledge cannot be written down in a book for anyone to understand	Strongly disagree	1 2 3 4 5 Strongly agree
25	My elders have understandings about the world that will only become known to me when I am old like them	Strongly disagree	1 2 3 4 5 Strongly agree
26	There are things the elders tell me to do that have no scientific explanation	Strongly disagree	1 2 3 4 5 Strongly agree
27	The wisdom about the world the elders possess is the unquestionable truth	Strongly disagree	1 2 3 4 5 Strongly agree
28	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	Strongly disagree	1 2 3 4 5 Strongly agree
29	Taboos have no scientific basis	Strongly disagree	1 2 3 4 5 Strongly agree
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	Strongly disagree	1 2 3 4 5 Strongly agree
31	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	Strongly disagree	1 2 3 4 5 Strongly agree

Note. I-ADCLOS = Instrument for Assessing Dispositions for Contextual Learning of Science.

We considered the instrument development and validation to be part of the assessment of the students' baseline dispositions toward science learning in their local contexts. The numerical (quantitative) values served as pointers or signposts to how students might act in contextualized science discourses (Thomas, Anderson, & Nashon, 2008), hence the reason for the interview that probed the students with regard to the emergent pointers resulting from exploratory factor analysis and as a way of further validation of the instrument.

All the interview data were transcribed verbatim for detailed analysis involving searching for expressions that reflected the content of the factors (dimensions) and subfactors (subdimensions), examining, categorizing, and testing assertions for reliability, and recombining evidence from the different interview transcripts with regard to description and interpretation of the emergent dimensions and subdimensions. This was done consistently with the objective of the study (Miles & Huberman, 1984; Yin, 2003). Analysis of interview data sets from different focus groups involved comparing within and across the sets to further clarify and interpret the quantitatively determined characteristics of the students with respect to their potential to develop dispositions for contextual learning of science. Informed by the literature reviewed and factor analysis, we were able to interpret the participating students' potential to be disposed toward learning science in their local context.

We individually and collectively reviewed the interview transcripts as well as videos by reading and reviewing back and forth, respectively (Dahlberg & Drew, 1997), as we searched for emergent themes that cut across focus interview groups who were representative of the participating students, and compared them with the quantitatively determined dimensions and subdimensions to ascertain their validity.

The Participants

The pilot group (n = 36) was an all gender, typical multiethnic, mixed ability, and social economic status Form 3 (Grade 11) science class in Kenya. The study group of science students (n = 261) were drawn from Form 3 science classes: two girls only (5 classes) and two mixed (4 classes) schools from selected schools that represent the main categories of public high schools in Kenya, national, provincial and district. National schools admit top students on quota basis from all the districts in Kenya. Provincial schools admit students on quota basis from districts within the province. Provincial schools tend to admit students who normally would have missed admission to national schools. District schools take students from the district where they are located. The students admitted to district schools are those who would normally have missed admission to national and provincial schools. In general, national schools admit the best students followed by the provincial and lastly district schools. However, due to extraneous circumstances, such as lack of school fees, some of the top students do choose to study in district schools, as most of the district schools are day schools and affordable. Also, there is flexibility to allow students who have performed well from other districts who fill up their quota to get admitted to national or provincial schools subject to availability of spaces/seats. In general, most schools have student demographics that reflect the cultural mosaic of Kenya.

It is worth noting that the five themes (AT_SJK, SLC, NOT_WKBS, NOS, and SK) around which the instrument's content was based were considered to be different angles from which students' disposition toward contextual learning of science could be probed or inferred. In other words, it is possible to assess and understand this phenomenon from these angles. In a way, this could be considered a form of triangulation (Mathison, 1988). Therefore, the instrument was expected to assess the same thing, that is, students' *disposition toward contextual learning of science*, which is the reason for ensuring its validity as well as reliability.

The I-ADCLOS

The initial theoretically determined components AT_SJK, SLC, NOT_WKBS, NOS, and SK comprised 7, 11, 9, 4, and 5 items, respectively. Each item was decided on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*; see Table 1a). Table 1a shows shaded items that were deleted following the validation process of reliability testing and factor analysis to yield a 31-item instrument (see Table 1b).

The results discussed in the next section follow from the analysis of questionnaire responses from a study group (n = 261) of students who participated in the study. This number is well within the recommended range of subjects to undertake validation and factor analysis (Costello & Osborne, 2005; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Ford, MacCallum, & Tait, 1986; Henson & Roberts, 2006).

Table 1c. Case Processing Summary.

Cases	n	%
Valid	29	80.6
Excluded[a]	7	19.4
Total	36	100.0

[a]Cases with incomplete data.

Table 1d. Reliability Statistics.

Cronbach's α	N of items
.628	31

Results

Validating the Instrument

Reliability analyses were performed on questionnaire data to assess the questionnaire's ability to consistently assess students' dispositions toward contextualized science learning. Processing of pilot data excluded seven invalid cases (Table 1c). Using valid pilot data (n = 29), the Cronbach's alpha reliability test was performed. With inspection and deletion of 5 items, the refined 31-item I-ADCLOS (Table 1b) stabilized at $\alpha = .628$ and enabled exploratory factor analysis to be performed.

Exploratory factor analysis generated three clusters of items (see Table 2a). We considered these clusters as tentative components or dimensions on which the 31 items loaded positively and reflected in the component transformation matrix (see Table 2b). Some of the items had very low loadings (<0.3) on all the three factors and others had loadings (≥0.3) on more than one factor.

Consequently, for the questionnaire to have been assessing students' dispositions toward contextual learning of science, each individual item should assess students' dispositions plus some amount of random error. A reliability coefficient (α) of .70 or higher is considered acceptable (Anderson & Nashon, 2007; Radhakrishna, 2007). As the reliability for the instrument on 29 cases (see Tables 1a and 1b) was .628, we proceeded to administer the instrument to a larger sample (n = 261). Similar exploratory analyses were performed and the reliability improved dramatically to $\alpha = .811$ (see Tables 3a, 3b, and 3c).

With the overall instrument reliability at $\alpha = .811$ and individual item reliabilities at $\alpha > .7$, we performed exploratory factor analysis of the data obtained from 220

Table 2a. Component Matrix.

No.		Component 1	Component 2	Component 3
1	No science is involved in making the Jua Kali products	.424	.380	.146
2	There can be no learning of science in the Jua Kali environment	.310	.482	.239
3	I find Jua Kali sheds in places where I can see the science I have learned in school	−.117	−.510	.055
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	−.032	.313	.732
5	The science we learn from school has no relevance to Jua Kali	.184	.040	.624
6	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	.362	.104	.043
7	It is not helpful to learn things that will not be tested on the exam	−.095	.659	−.325
8	Science activities including Jua Kali are only useful if they can help me in passing exams	.095	.675	.233
9	My knowledge of science is developed through discussions with my classmates	.436	−.409	.475
10	Working together in groups helps me learn science better than working on my own	.315	−.305	−.368
11	I understand science better when I share my views with my brothers and sisters (or family)	−.084	.194	−.618
12	I am comfortable sharing my knowledge with closest friends	−.050	.306	−.057
13	I make sense of the things I learn in school when I read them over several times	.134	−.368	−.156
14	I memorize science ideas that I suspect will appear on the test or exam	.143	.169	.389
15	I can never be satisfied with my experimental results until my classmates have the same	.696	−.188	.250
16	I can never be satisfied with my experimental results until my teacher marks it	.740	−.025	−.033
17	How I conduct and understand science is not in any way influenced by my religious faith	−.093	.277	−.031
18	How I conduct and understand science is not in any way influenced by my culture	−.121	.363	.117
19	There are things in the world around me that cannot ever be explained by science	.478	.132	−.022
20	I accept that there are explanations for natural phenomena that cannot be provided by science	.593	.205	−.207
21	I never question the correctness of our cultural taboos	.425	.493	−.160
22	Science can explain the lightening phenomenon better than our cultural interpretation	−.456	−.158	.283
23	The traditional doctor's knowledge cannot be known by just anyone	.346	−.173	.317
24	The traditional doctor's knowledge cannot be written down in a book for anyone to understand	.262	−.001	.141
25	My elders have understandings about the world that will only become known to me when I am old like them	.597	.240	−.361
26	There are things the elders tell me to do that have no scientific explanation	.530	−.324	.041
27	The wisdom about the world the elders possess is the unquestionable truth	−.234	.445	−.033
28	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	.564	−.038	.241
29	Taboos have no scientific basis	.324	.073	−.397
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.423	−.219	−.529
31	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	.193	−.209	−.119

Note. Three components were extracted. Extraction method: Principal components analysis.

Table 2b. Component Transformation Matrix.

Component	1	2	3
1	.903	−.243	.354
2	.273	.961	−.038
3	−.331	.131	.935

Note. Extraction method: Principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 3a. Case Processing Summary.

Cases	*n*	%
Valid	220	84.3
Excluded[a]	41	15.7
Total	261	100.0

[a]Listwise deletion was based on all variables in the procedure.

Table 3b. Reliability Statistics.

Cronbach's α	*N* of items
.811	31

Note. Furthermore, individual item reliabilities of the 31 items were α > .7 (see Table 3c).

Table 3c. Item-Total Statistics.

		Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's α if item deleted
1	No science is involved in making the Jua Kali products	67.4455	187.052	−.065	.814
2	There can be no learning of science in the Jua Kali environment	67.1455	189.568	−.192	.818
3	I find Jua Kali sheds places where I can see the science I have learned in school	67.2364	184.611	.080	.812
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	67.0545	182.289	.186	.810
5	The science we learn from school has no relevance to Jua Kali	67.2182	185.660	.017	.814
6	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	66.8591	175.428	.313	.806
7	It is not helpful to learn things that will not be tested on the exam	67.1364	190.283	−.213	.820
8	Science activities including Jua Kali are only useful if they can help me in passing exams	67.1955	186.176	−.010	.814
9	My knowledge of science is developed through discussions with my classmates	65.1409	169.628	.423	.801
10	Working together in groups helps me learn science better than working on my own	65.5864	162.618	.529	.795
11	I understand science better when I share my views with my brothers and sisters (or family)	65.8273	168.354	.454	.800
12	I am comfortable sharing my knowledge with closest friends	65.6818	169.679	.388	.803
13	I make sense of the things I learn in school when I read them over several times	64.2591	186.038	−.021	.817
14	I memorize science ideas that I suspect will appear on the test or exam	65.7909	175.773	.222	.811
15	I can never be satisfied with my experimental results until my classmates have the same	67.3227	182.420	.244	.809
16	I can never be satisfied with my experimental results until my teacher marks it	67.1818	181.136	.252	.808
17	How I conduct and understand science is not in any way influenced by my religious faith	66.2955	162.154	.547	.794
18	How I conduct and understand science is not in any way influenced by my culture	66.7227	161.781	.587	.793
19	There are things in the world around me that cannot ever be explained by science	67.0045	184.781	.054	.813
20	I accept that there are explanations for natural phenomena that cannot be provided by science	66.9318	163.525	.633	.792
21	I never question the correctness of our cultural taboos	67.0545	171.796	.438	.801
22	Science can explain the lightening phenomenon better than our cultural interpretation	66.3182	155.268	.688	.786
23	The traditional doctors' knowledge cannot be known by just anyone	66.5864	171.614	.374	.804
24	The traditional doctors' knowledge cannot be written down in a book for anyone to understand	66.5636	170.311	.443	.801
25	My elders have understandings about the world that will only become known to me when I am old like them	67.1136	178.393	.264	.808

(continued)

Table 3c. (continued)

		Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's α if item deleted
26	There are things the elders tell me to do that have no scientific explanation (e.g., don't sweep the house at night)	65.6864	170.024	.377	.803
27	The wisdom about the world the elders possess is the unquestionable truth	66.8182	183.994	.089	.812
28	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	67.0364	185.131	.040	.813
29	Taboos have no scientific basis	66.8091	166.100	.596	.794
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	65.0091	169.041	.427	.801
31	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	66.4682	175.008	.295	.807

acceptable cases out of the initial 261. This time the items loaded higher (≥0.3) on at least one of the components and still clustered around three components (Table 4). The shaded factor loadings (Tables 4; 5a, 5b, 5c; 6, 6a, 6b; 7, 7a, 7b; 8, 8a, 8b) indicate the items that constitute the factor or component. An item can only be considered under a factor or component to which it has highest loading value and is ≥0.3. It should be pointed out that we considered a factor significant if it were loaded with three or more items.

The alpha reliabilities for the three Components 1 (12 items), 2 (11 items), and 3 (8 items) had $\alpha_1 = .869$, $\alpha_2 = .669$, and $\alpha_3 = 0.507$, respectively, and respective variances explained as 17.659%, 8.434%, and 6.714%. In other words, the total variance explained by these components or factors (dimensions) was 32.805%.

Extracting the items that loaded on Component (dimension) 1 (Table 5a) and carefully considering the meaning of what they convey, we find them pointing to awareness. Also, a number of items are about traditional knowledge. Mostly these items convey what traditional knowledge cannot do. We see in these items indications of limitations of traditional knowledge. Hence, we interpret and describe Component or Dimension 1 as "Personal Awareness of Influences on Learning Science and Limitations of Traditional Knowledge" (PA_ILS_LTK). Similarly, items that loaded on Component (dimension) 2 were extracted and reflected on with a view to interpreting and describing this cluster of items (see Table 5b).

Conveyed in these items is the attitude toward learning science in Jua Kali and nature of traditional knowledge. We revisited the literature reviewed earlier, especially on attitudes (Hodson, 1998), where it was expressed that "what the students choose to learn, how they learn it, and when to learn it" (Hodson, 1998; Nashon, 2005, Nashon & Nielsen, 2007) is a function of attitude. Thus, we described and interpreted Component (dimension) 2 as "Attitudes Towards Science Learning in Local Contexts and Nature of Traditional Knowing" (AT_SLiLC_NoTK). Finally, the items that loaded on Component (dimension) 3 were similarly extracted, examined, described, and interpreted (see Table 5c).

Using Gitari's (2006) analysis of a Kenyan community's knowledge of health and healing that showed personal learning tools, relational learning tools, genres of moral obligation, and genres of *knowledge guarding* as unique and indigenous ways of learning and knowing complemented by Jegede's (1995, 1996) notion of collateral learning whereby an indigenous learner holds scientific views and traditional views side by side, we were able to discern elements of this in the aforementioned cluster of items. Thus, we interpreted and described Component (dimension) 3 as "Orientation Towards Collateral and Personal Learning Strategies" (OTC_PLS).

To understand these dimensions, we performed further factor analysis on each to determine the subdimensions that characterize them. Thus, we were able to extract two subdimensions from each dimension as shown in Tables 6, 6a, and 6b; 7, 7a, and 7b; and 8, 8a, and 8b. We followed similar procedures as in the extraction of Components 1, 2, and 3 for interpretation and description.

Although the extraction of subcomponents followed the procedures for factor analysis of the whole instrument, we adopted similar procedures to reveal the characteristics of each factor, which we considered to be factors characterizing the main components. In this paper, we used factors, components, and dimensions interchangeably. Similarly factor analysis of each dimension resulted in subdimensions (subfactors or subcomponents). We considered this approach to the extraction of subfactors to be appropriate because factor analysis requires at least three items for meaningful interpretation (Kim & Mueller, 1978).

We considered the subdimensions to describe key characteristics of the principal components underlying the instrument assessment of the construct: disposition to contextual learning of science. As conveyed, factor analysis of each component revealed subcomponents. These we interpreted and described as (a) PA_ILS_LTK (see Table 6): independence of science learning from cultural influences (see Table 6a) and metacognitive learning (see Table 6b); (b) AT_SLiLC_NoTK (see Table 7): instrumentalist–culturalist perspectives (see Table 7a) and exam-centered and

Table 4. Rotated Component Matrix.

No.		Component 1	2	3
22	Science can explain the lightening phenomenon better than our cultural interpretation	.825	−.018	.164
20	I accept that there are explanations for natural phenomena that cannot be provided by science	.774	−.032	.124
18	How I conduct and understand science is not in any way influenced by my culture	.768	−.052	.069
17	How I conduct and understand science is not in any way influenced by my religious faith	.687	−.020	.054
29	Taboos have no scientific basis	.673	.113	.164
21	I never question the correctness of our cultural taboos	.614	.000	−.009
10	Working together in groups helps me learn science better than working on my own	.600	−.270	.294
11	I understand science better when I share my views with my brothers and sisters (or family)	.464	−.022	.304
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.458	−.205	.281
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.458	−.205	.281
24	The traditional doctors' knowledge cannot be written down in a book for anyone to understand	.443	.128	.336
12	I am comfortable sharing my knowledge with closest friends	.342	−.038	.337
26	There are things the elders tell me to do that have no scientific explanation (e.g., don't sweep the house at night).	.425	−.092	.274
19	There are things in the world around me that cannot ever be explained by science	.002	.508	.046
27	The wisdom about the world the elders possess is the unquestionable truth	−.049	.481	.212
16	I can never be satisfied with my experimental results until my teacher marks it	.289	.467	.030
8	Science activities including Jua Kali are only useful if they can help me in passing exams	−.048	.583	−.114
3	I find Jua Kali sheds in places where I can see the science I have learned in school	−.007	.541	.008
5	The science we learn from school has no relevance to Jua Kali	−.189	.539	.181
2	There can be no learning of science in the Jua Kali environment	−.308	.457	−.099
15	I can never be satisfied with my experimental results until my classmates have the same	.296	.441	.038
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	.216	.430	−.065
7	It is not helpful to learn things that will not be tested on the exam	−.374	.394	.033
28	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	−.166	.319	.309
6	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	.121	.104	.539
31	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	.097	−.034	.533
14	I memorize science ideas that I suspect will appear on the test or exam	.013	.212	.437
9	My knowledge of science is developed through discussions with my classmates	.404	−.329	.419
23	The traditional doctors' knowledge cannot be known by just anyone	.298	−.123	.404
25	My elders have understandings about the world that will only become known to me when I am old like them	.129	.032	.376
1	No science is involved in the making of Jua Kali products	−.305	.145	.312
13	I make sense of the things I learn in school when I read them over several times	−.206	−.197	.308

Note. Rotation converged in eight iterations. Extraction method: Principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 5a. Component 1.

22	Science can explain the lightening phenomenon better than our cultural interpretation	.825	−.018	.164
20	I accept that there are explanations for natural phenomena that cannot be provided by science	.774	−.032	.124
18	How I conduct and understand science is not in any way influenced by my culture	.768	−.052	.069
17	How I conduct and understand science is not in any way influenced by my religious faith	.687	−.020	.054
29	Taboos have no scientific basis	.673	.113	.164
21	I never question the correctness of our cultural taboos	.614	.000	−.009
10	Working together in groups helps me learn science better than working on my own	.600	−.270	.294
11	I understand science better when I share my views with my brothers and sisters (or family)	.464	−.022	.304
30	There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.458	−.205	.281
24	The traditional doctors' knowledge cannot be written down in a book for anyone to understand	.443	.128	.336
12	I am comfortable sharing my knowledge with closest friends	.342	−.038	.337
26	There are things the elders tell me to do that have no scientific explanation (e.g., don't sweep the house at night)	.425	−.092	.274

Table 5b. Component 2.

19	There are things in the world around me that cannot ever be explained by science	.002	.508	.046
27	The wisdom about the world the elders possess is the unquestionable truth	−.049	.481	.212
16	I can never be satisfied with my experimental results until my teacher marks it	.289	.467	.030
8	Science activities including Jua Kali are only useful if they can help me in passing exams	−.048	.583	−.114
3	I find Jua Kali sheds in places where I can see the science I have learned in school	−.007	.541	.008
5	The science we learn from school has no relevance to Jua Kali	−.189	.539	.181
2	There can be no learning of science in the Jua Kali environment	−.308	.457	−.099
15	I can never be satisfied with my experimental results until my classmates have the same	.296	.441	.038
4	Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	.216	.430	−.065
7	It is not helpful to learn things that will not be tested on the exam	−.374	.394	.033
28	There are things that I know about traditional treatment and healing of diseases that I cannot share with others	−.166	.319	.309

Table 5c. Component 3.

6	I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	.121	.104	.539
31	The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	.097	−.034	.533
14	I memorize science ideas that I suspect will appear on the test or exam	.013	.212	.437
9	My knowledge of science is developed through discussions with my classmates	.404	−.329	.419
23	The traditional doctors' knowledge cannot be known by just anyone	.298	−.123	.404
25	My elders have understandings about the world that will only become known to me when I am old like them	.129	.032	.376
1	No science is involved in the making of Jua Kali products	−.305	.145	.312
13	I make sense of the things I learn in school when I read them over several times	−.206	−.197	.308

textbook/teacher reliant learners (see Table 7b); and (c) OTC_PLS (see Table 8): personal awareness of successful learning strategies and other ways of knowing (see Table 8a) and privileging science and learning by rote (see Table 8b).

Variance Explained

These three components or factors explain 32.805 of the total variance distributed as follows.

PA_ILS_LTK. A total of 17.657% of the variance of contextual learning of science by the participants is attributed to this factor. Subsequently, two subcomponents characterize this factor (dimension or component), which we have described and interpreted as independence of science learning from cultural influences (see Table 6a) and with expected variance explained being 27.385% and 23.251%, respectively. In other words, these subdimensions account for 50.686% of contextual learning attributed to PA_ILS_LTK.

AT_SLiLC_NoTK. A total of 8.434% of the variance to contextual learning of science is explained by this factor. And, the two subdimensions, instrumentalist–culturalist perspectives and exam-centered and textbook/teacher reliant learning, which characterize AT_SLiLC_NoTK explain 20.011 % and 16.138% of variance, respectively. This means that these two subdimensions can explain 36.149% of variance explained by AT_SLiLC_NoTK.

Table 6. Personal Awareness of Influences on Learning Science and Limitations of Traditional Knowledge (PA_ILS_LTK): Extraction of Subdimensions (Rotated Component Matrix).

	Component	
Items	1	2
How I conduct and understand science is not in any way influenced by my religious faith	.800	.196
I never question the correctness of our cultural taboos	.772	.055
How I conduct and understand science is not in any way influenced by my culture	.755	.285
Science can explain the lightening phenomenon better than our cultural interpretation	.657	.545
Taboos have no scientific basis	.607	.398
I understand science better when I share my views with my brothers and sisters (or family)	.161	.656
The traditional doctors' knowledge cannot be written down in a book for anyone to understand	.037	.675
I accept that there are explanations for natural phenomena that cannot be provided by science	.503	.633
There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.199	.588
Working together in groups helps me learn science better than working on my own	.406	.579
There are things the elders tell me to do that have no scientific explanation (e.g., don't sweep the house at night)	.334	.353
I am comfortable sharing my knowledge with closest friends	.291	.348

Note. Rotation converged in three iterations. Extraction method: Principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 6a. Subdimension 1 (Independence of Science Learning From Cultural Influences).

How I conduct and understand science is not in any way influenced by my religious faith	.800	.196
I never question the correctness of our cultural taboos	.772	.055
How I conduct and understand science is not in any way influenced by my culture	.755	.285
Science can explain the lightening phenomenon better than our cultural interpretation	.657	.545
Taboos have no scientific basis	.607	.398

Table 6b. Subdimension 2 (Metacognitive Learning).

The traditional doctors' knowledge cannot be written down in a book for anyone to understand	.037	.675
I understand science better when I share my views with my brothers and sisters (or family)	.161	.656
I accept that there are explanations for natural phenomena that cannot be provided by science	.503	.633
There are other ways for me to learn science other than from the teacher, the classroom, or the textbook	.199	.588
Working together in groups helps me learn science better than working on my own	.406	.579
There are things the elders tell me to do that have no scientific explanation (e.g., don't sweep the house at night)	.334	.353
I am comfortable sharing my knowledge with closest friends	.291	.348

OTC_PLS. The 6.714% of the variance attributed to contextual learning of science can be explained by this factor. Furthermore, the subdimensions, personal awareness of successful learning strategies and other ways of knowing and privileging science and learning by rote, can explain 20.430% and 16.149% variance, respectively. Thus, these two subdimensions can explain a total of 36.579 % of the variance attributed to this factor.

Prior to engaging in a curriculum experience that integrated classroom and Jua Kali learning experiences, select groups of participants were interviewed as a way of probing the viability of the characteristics that underlay the three dimensions and six subdimensions extracted in a factor analysis process. It was an open-ended interview where students' attitudes with regard to learning science in their local context, Jua Kali; learning styles; and views of traditional knowledge were probed. The questions asked covered a wide range of topics including how best they learn science, how they see the role of religion and culture in their understanding of science, and where Jua Kali artisans get their knowledge from and whether it has any connection to science.

Using qualitative methods of analyzing the interview data corpus, we read the interview transcripts back and forth to see if there were ideas expressed that were consistent with the extracted subfactors as these were characteristics that underlay the three components of the instrument. In other words, we coded the data according to the subfactors listed in the following text. In most cases, the statements reflected more than one subfactor or characteristic:

Table 7. Attitudes Toward Science Learning in Local Contexts and Nature of Traditional Knowing (AT_SLiLC_NoTK): Extraction of Subdimensions (Rotated Component Matrix).

	Component	
Items	1	2
There can be no learning of science in the Jua Kali environment	.691	−.096
It is not helpful to learn things that will not be tested on the exam	.621	−.154
The science we learn from school has no relevance to Jua Kali	.579	.205
I find Jua Kali shades places where I can see the science I have learned in school	.463	.283
There are things in the world around me that cannot ever be explained by science	.476	.234
The wisdom about the world the elders possess is the unquestionable truth	.446	.280
There are things that I know about traditional treatment and healing of diseases that I cannot share with others	.439	.025
I can never be satisfied with my experimental results until my classmates have the same	−.072	.676
I can never be satisfied with my experimental results until my teacher marks it	.029	.670
Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	.122	.562
Science activities including Jua Kali are only useful if they can help me in passing exams	.386	.514

Note. Rotation converged in three iterations. Extraction method: Principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 7a. Subdimension 1 (Instrumentalist–Culturalist Perspectives).

There can be no learning of science in the Jua Kali environment	.691	−.096
It is not helpful to learn things that will not be tested on the exam	.621	−.154
The science we learn from school has no relevance to Jua Kali	.579	.205
There are things in the world around me that cannot ever be explained by science	.476	.234
I find Jua Kali sheds in places where I can see the science I have learned in school	.463	.283
The wisdom about the world the elders possess is the unquestionable truth	.446	.280
There are things that I know about traditional treatment and healing of diseases that I cannot share with others	.439	.025

Table 7b. Subdimension 2 (Exam-Centered, Textbook/Teacher Reliant Learners).

I can never be satisfied with my experimental results until my classmates have the same	−.072	.676
I can never be satisfied with my experimental results until my teacher marks it	.029	.670
Learning science in a Jua Kali environment is difficult because there are no books that explain science in terms of Jua Kali	.122	.562
Science activities including Jua Kali are only useful if they can help me in passing exams	.386	.514

Table 8. Orientation Toward Collateral and Personal Learning Strategies (OTC_PLS): Extraction of Subdimensions (Rotated Component Matrix).

	Component	
Items	1	2
The traditional doctors' knowledge cannot be known by just anyone	.717	−.038
My knowledge of science is developed through discussions with my classmates	.681	.026
The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	.547	.260
I make sense of the things I learn in school when I read them over several times	.275	.038
No science is involved in making the Jua Kali products	−.245	.674
My elders have understandings about the world that will only become known to me when I am old like them	.109	.652
I memorize science ideas that I suspect will appear on the test or exam	.295	.431
I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	.350	.394

Note. Rotation converged in three iterations. Extraction method: Principal components analysis. Rotation method: Varimax with Kaiser normalization.

Table 8a. Subdimension 1 (Personal Awareness of Successful Learning Strategies and Other Ways of Knowing).

The traditional doctors' knowledge cannot be known by just anyone	.717	−.038
My knowledge of science is developed through discussion with my classmates	.681	.026
The traditional doctor has knowledge about how to treat sick people that I can never hope to understand	.547	.260
I make sense of the things I learn in school when I read them over several times	.275	.038

Table 8b. Subdimension 2 (Privileging Science and Learning by Rote).

No science is involved in making the Jua Kali products	−.245	.674
My elders have understandings about the world that will only become known to me when I am old like them	.109	.652
I memorize science ideas that I suspect will appear on the test or exam	.295	.431
I always hold back my ideas in class because I like to surprise my teachers and friends on the exam (performance)	.350	.394

- Independence of science learning from cultural influences
- Metacognitive learning
- Instrumentalist–culturalist
- Exam-centered, textbook/teacher reliant learners
- Personal awareness of successful learning strategies and other ways of knowing
- Privileging science and learning by rote.

In response to open-ended questions regarding the feelings about having a fieldtrip to a Jua Kali shed, the students were metacognitive about their learning and expressed awareness of learning strategies that they considered successful with respect to out-of-school contexts. It should be pointed out that this method of teaching and learning science is atypical in Kenyan schools despite the fact that the syllabus has objectives to this effect. Also, the teachers had during a preparatory workshop expressed pessimism at the students' response to the idea of learning science in a Jua Kali context, citing the negative perception and low status of the jobs in the sector, rightly due to some of the insecurity associated with the sector. The sentiments were summarized by one of our research assistants who facilitated a preparatory workshop for the teachers on the need to use local contexts in teaching science and development of science curricular units that integrated classroom and Jua Kali experiences without violating the mandated curriculum:

RA: [Workshop] participants from MG high school expressed the challenge in engaging students from their school in applying [science] knowledge to the Jua Kali sector, as they are likely not to perceive it as having status in the socioeconomic setting. There is the need to help students deconstruct the perception of Jua Kali as it is often perceived as a sector for failures in the education system. Yet students from MG, given their social backgrounds, aspire to go to the university . . . [or] higher level academically oriented technology . . . professions more geared toward the industrial sector as engineers.

However, when the students were interviewed about how they felt about the possibility of learning science at a Jua Kali shed, they were very metacognitive and displayed knowledge of personal learning strategies they felt were effective or less effective. Such statements were coded under two subdimensions or characteristics: metacognitive learning and personal awareness of successful learning strategies and other ways of knowing, as illustrated by the excerpts below:

Erica: I think when you relate science to situations in life, like in real life situations it becomes more practical. Okay we may not be able to go out all the time and have these field trips but when you relate science to real life practical things that we do in everyday life it becomes more applicable and science becomes easier to understand.

Lin: I was interested in science and outdoor activities. You know learning of science is concentrated in class. Supposing we open our minds and go outside in our environment. It got me thinking of learning science beyond the classroom.

Fay: I think reading and understanding, then seeing it practically, even doing it at some point, I think I am actually seeing the fun part of science.

These excerpts demonstrate *reflective thinking*, which is very characteristic of metacognitive thinking (Anderson & Nashon, 2007; Gunstone, 1994; Nashon & Anderson, 2004). Also, apart from being metacognitive, there was demonstrated awareness of effective and less effective learning strategies that were in a way exam driven or centered. It appears that these students whose voices appear to represent many others in Kenyan schools strongly endorse the view that science learning can be more meaningful if the science curriculum were contextualized. By visiting Jua Kali sheds, Erica, Lin, and Fay easily made connections between the science they were taught in class and the science they experienced being applied in the Jua Kali sheds. This in itself may influence the way the students approach science as illustrated in their views. As has already been argued, perceptions of industrialization (embodied in science and technology and implied in the Kenya Government vision—MPET, 1997-2010) 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, influencing students' views of contextualized learning of science require engaging them in science discourses that link classroom science to the real world of Jua Kali activities. In other words, influencing students' views or perceptions require learning enablers that are situated in the students' sociocultural environments such as Jua Kali. For example, in the case of Erica, relating classroom science to Jua Kali science made learning science more practical. Lin wondered what other opportunities would be opened if one was open minded to linking the two while Fay saw the fun part of learning science in the Jua Kali sheds. 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; Mintzes, Wandersee, & Novak, 1997, 1998). The social setting in this regard is the Jua Kali where they interacted with artisans.

Besides being coded under metacognitive learning and personal awareness of successful learning strategies and other ways of knowing, the following excerpts also intersected with exam-centered and textbook/teacher reliant learners and privileging science and learning by rote:

Sally: 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.

Erica: When I cram I forget it after the exam. That is why I turn to my mapping to help me visualize.

Fay: I really hate cramming because I prefer actually reading a month before the exam. I actually get bored with subjects, so if I read something and I don't understand it, I just cram it and then I do the exam and forget about it. Then again I have to come back and read because I just get so bored. I prefer to know something than cram and forget.

Cramming in our view is a strategy that is aimed at achieving a threatening goal, say passing an exam. Failure is a threat and cramming for these kinds of learners is meant to prevent failure. In other words, this could be driven by the "better something on paper compared with none" strategy. Nonetheless, the three students, Sally, Erica, and Fay, demonstrated a high degree of *metacognition* by being aware and in control of their learning strategies; they are aware of strategies that can earn them successful learning. They seem to realize that the existing science curriculum and instruction model is 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) claimed to involve the mind that naturally seeks meaning in a context for relationships that make sense and resonate with one's sociocultural background. Thus, one can say that in Sally's, Erica's, and Fay's views, Kenyan schools would benefit from a science curriculum that contextualized student learning. These students demonstrate a high level of *metacognition* by being aware and in control of their learning strategies.

In general, consistent with the PA_ILS_LTK dimension, the students expressed awareness of effective science learning strategies and influences on their science learning.

Erica: Science needs to be practical; it needs to be related to something, to be given contrast to something. So it becomes really interesting and you actually get the concepts. But where there is so much theory it's also a bit hard to understand.

Mercy: Some students need experiments to be able to understand concepts better because you will find that subjects like biology. Some students live in towns and so they don't know other names of the native plants or other animals so they have to be shown. They need experiments or field study.

Shanon: Mine is in chemistry a topic called structure and bonding. The teacher did a very good presentation and we saw it practically and we understood it better. She used the model, which was very clear and I was able to visualize what an atom . . . is.

Dai: Mine was a topic on classification. We went out a lot; we got various specimens out there about various living things. So we saw a lot of organisms until now I still understand a lot. We collected a lot of specimens.

Vera: [Through] discussion you get to know more. This can be with peers even when you are home during the holidays just go and share with people from other schools then you get to know more and understand it (ideas/concepts) better.

It also emerged from these interviews that apart from the students having diverse views of what culture is, which they defined based on their lifestyles and where they live, they recognized its place as conveyed in the excerpts following questions that sought understanding of culture and how it affected them. We coded these under the independence of science learning from cultural influences, instrumentalist–culturalist, and Personal awareness of successful learning strategies and other ways of knowing dimension:

Caro: Culture is what our ancestors and the society believe in but I believe they are not useful now.

Elly: When the culture is not there you will not be bonded into that ethnic group.

Deb: Culture is actually what you live, what your life is, what practices, what values you are taught . . . There is also that aspect that . . . you still connect to your ethnicity.

Paige: Culture . . . [is] the practices, . . . all the taboos, and all the restrictions.

Dorothy: Some of the cultures require familiarity with them but I am not used to going to my rural place. So some of the questions I found to be very difficult to answer.

The three dimensions, PA_ILS_LTK, AT_SLiLC_NoTK, and OTC_PLS, are also reflected in the literature. Studies on student metacognition have shown that students who are aware and in control of their own learning process including awareness of the strategies they successfully use to learn become more empowered learners (Anderson & Nashon, 2007; Anderson, Nashon, & Thomas, 2009; Gunstone, 1994; Nashon & Anderson, 2004; Thomas et al., 2008).

Low enrolment in physics has been linked to factors such as attitudes toward and emotional connections to physics (Fischer & Horstendahl, 1997; Nashon & Nielsen, 2007; Rowsey, 1997). And, studies among African and First Nations students in Canada have revealed that scientific and alternative frameworks can coexist, a phenomenon Jegede (1995, 1996) and Aikenhead and Jegede (1999) called collateral learning. In some cases, students have been found to segregate against certain views depending on the context, which is sometimes referred to as a cognitive apartheid (Cobern, 1996; Cobern & Aikenhead, 1998; Young, 1992). The following excerpts serve to further illuminate the validity of the OTC_PLS dimension:

Interviewer: How do you reconcile the two perspectives on religion and science in your learning environment? Does it create contradictions to you as an individual when you are learning science?

Fay: I think I have my knowledge in religion and my knowledge in science, so there is no much of contradiction. I see them as separate issues.

Deb: I am trying to think of something about science that it is also a discipline that respects religion because there are aspects of life that science cannot explain . . . Science has also defined itself and it respects matters of religion because no one can tell me how I was given life, no one can tell me how my soul lives, no one can tell me how I have this soul in me. It is only God who can tell me that. And science has not tried to tell me that this is what is happening to your soul.

Conclusion

The construction of the initial 36-item instrument was informed by theory and experience with a special focus on AT_SJK (7 items), SLC (11 items), NOT_WKBS (9 items), NOS (4 items), and SK (5 items) as ways of developing items that captured as wide a scope as possible to triangulate the students' dispositions toward contextual learning of science.

The results of factor analysis using questionnaire data from 220 valid cases of the initial 261 participants from selected high schools revealed factors or dimensions that were defined differently, although some of the content of the original concepts influenced the redefinition of the factors that reflected this population of students more. It is possible that different factors can be extracted if the instrument is administered to a different population of students outside the Kenyan context. Furthermore, as already pointed out, reliability tests as well as factor analyses supported the stability of these dimensions whose characteristics have been reflected in group interview data on questions related to students' dispositions toward learning science in local contexts.

Normally, a scale of alpha reliability greater or equal to .7 is acceptable. Nonetheless, we retained the OTC_PLS dimension ($\alpha_3 = .507$) because of the strong qualitative and theoretical validity and very high individual item reliabilities on the main scale I-ADCLOS. Jegede (1995, 1996) and Aikenhead and Jegede (1999) have demonstrated the prevalence of collateral learning among continental African and First Nations students. The equivalent in Western cultures is what some scholars call cognitive apartheid (Cobern, 1996; Cobern & Aikenhead, 1998; Young, 1992). According to Cobern (1996), the students simply wall off the concepts that do not fit their natural worldviews and instead create a compartment for scientific knowledge from which it can be retrieved on special occasions, such as school exams. Moreover, as Young (1992) noted,

> this is likely to be more common if the new challenges the old. Under such circumstances, it is difficult for the new knowledge to be really made the pupil's own, a part of reality. It gets learned in a shallow way and . . . easily forgotten after the last examination, if it was ever really understood in the first place. (p. 23)

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