

EAST AFRICAN STUDENTS' WAYS OF KNOWING IN SCIENCE DISCOURSES

SUMMARY

The proposed study seeks to examine East African students' *Ways of Knowing* in science through a case study of selected Kenyan schools. We regard *Ways of Knowing* (WOK) in science to be the tools that learners use to construct their worldviews of science. Moreover, we consider worldviews of science to be inherently laden with the values and assumptions that become manifest in the learners' development and interpretation of scientific knowledge. Students' WOK are shaped by their socio-cultural backgrounds that in turn translate into their worldviews and perceptions of science. The study will investigate East African students' WOK through team-developed science activities that integrate analysis of conventional science curriculum (classroom) with Jua Kali (an informal sector defined by UNESCO as "small-scale manufacturing and technology-based services") production activities. Informality is used here to mean doing things characterised by ease of entry, reliance on indigenous resources, small scale operations, and labour intensive and adaptive technology (UNESCO, 1997).

There are several compelling reasons for examining East African (EA) students' WOK through integrated classroom-Jua Kali science curriculum experiences: 1) understanding how students see the world and harnessing this understanding will enable the development of better learning experiences; 2) Emergent research suggests that WOK are broader than those implied in the traditional Western thought (Aikenhead & Jegede, 1996; Guerts, 2002, Nashon, 2004, 2005) and, hence, examining EA students' WOK will enlighten further our current understandings of how people make meaning of the world; 3) We strongly believe that recognising the relationship between classroom science and the science imbedded in the "Jua Kali" (real world) production activities, is a key step towards the attempt to industrially revolutionise this sector to the benefit of EA. Thus, we see it as imperative that EA school-leavers (graduates) see the links between classroom science and the real world embodied in the case of Jua Kali; 4) Many (about 3/4) EA school-leavers join Jua Kali every year, and thus, understanding students' WOK will inform education programs through which the majority of Jua Kali artisans are prepared to the ultimate benefit of EA.

We have formed a trans-national collaborative – The Canadian-East African Collaborative for the Study of Ways of Knowing (CEACSWOK), which will investigate East African students' WOK through a science curriculum that integrates classroom and Jua Kali experiences with a view to elucidating students' WOK in the context of local Jua Kali production activities. CEACSWOK comprises Dr. Samson Nashon and Dr. David Anderson from the University of British Columbia (UBC) as principal investigators and Dr. Henry E. Embeywa from Kenyatta University, Kenya, as a collaborator. The study will focus on Kenya to investigate and elucidate other WOK outside of those implied in the traditional Western thought. The core research questions are:

- 1) What WOK are evident among East African students before, during, and 6 months after experiencing one year of integrated classroom and Jua Kali science curriculum?
- 2) What Jua Kali related experiences and attributes are key to evoking, engaging and revealing the students' WOK?
- 3) What are students' perceptions of Jua Kali centres as places for experiencing science?
- 4) What student views of science and WOK are imbedded in these perceptions?

- 5) How are the students' perceptions of science and WOK affected as they experience an integrated classroom-Jua Kali science curriculum including the ways they invoke and contextualise Jua Kali-related experiences during subsequent science discourses?
- 6) What new theoretical understandings about the students' views of science can be discerned from the emergent analysis of the students' WOK?

We (UBC team) are seeking SSHRC funding to realise CEACSWOK's endeavours of understanding EA students' WOK and develop new theoretical insights beyond the traditional Western conceptualisation of WOK.

OBJECTIVES

This proposed study seeks to understand East African (EA) students' *Ways of Knowing* (WOK) in science through case studies of science students from selected Kenyan schools. Specifically, the study seeks to understand:

- 1) What WOK are evident among East African students before, during, and 6 months after experiencing one year of integrated classroom and Jua Kali science curriculum?
- 2) What Jua Kali related experiences and attributes are key to evoking, engaging and revealing the students' WOK?
- 3) What are students' perceptions of Jua Kali centres as places for experiencing science?
- 4) What student views of science and WOK are imbedded in these perceptions?
- 5) How are the students' perceptions of science and WOK affected as they experience an integrated classroom-Jua Kali science curriculum including the ways they invoke and contextualise Jua Kali-related experiences during subsequent science discourses?
- 6) What new theoretical understandings about the students' views of science can be discerned from the emergent analysis of the students' WOK?

Context

To attempt to answer the study's core research questions, we have formed the *Canadian-East African Collaborative for the Study of Ways of Knowing* (CEACSWOK), which will investigate and elucidate EA students' WOK invoked and engaged as they experience integrated classroom-Jua Kali science curriculum activities. These activities will be co-developed by CEACSWOK team and the participant teachers. The CEACSWOK research team includes researchers from the University of British Columbia (UBC), Canada and Kenyatta University (KU), Kenya. Dr. Samson Nashon and Dr. David Anderson of UBC are the principal investigators while Dr. Henry E. Embeywa of KU is a collaborator. SSHRC funding for the UBC team's participation in CEACSWOK, will support this unique opportunity to better understand EA students' WOK and worldviews of science, and develop new theoretical understandings about WOK as we explore the phenomenon beyond a traditional Western conceptualisation of WOK.

LITERATURE & BACKGROUND:

Over the last two decades an informal (characterised by ease of entry, reliance on indigenous resources, small scale operations, and labour intensive and adaptive technology) (UNESCO, 1997) sector, known as “Jua Kali”¹, evolved into the largest employer of school-leavers (graduates) in East Africa (EA) (Kenya, Uganda & Tanzania) (Maundu, 1997; McLeanand & Kamau, 1999). It has become the most direct pathway for securing employment by high school-leavers compared to securing employment in the diminishing formal sector. This sector comprises jobs ranging from servicing or repairing of say, automobiles, to small-scale manufacturing of goods for local use (UNESCO, 1997). Yet there is no strong curriculum link between activities in the Jua Kali, school science (classroom knowledge), and their WOK. To most young East Africans, Jua Kali activities constitute part of their common socio-cultural environment. WOK are to a large extent culturally shaped (Cobern, 1998; Falk, 2001). Moreover, there is an ongoing rhetoric, which has now been entrenched in EA countries’ development plans (E.g., The 1997-2010 Republic of Kenya Master Plan on Education and Training, MPET, 1998), to be industrialised by the year 2020². This vision of industrialisation appears cannot be completely realised without understanding how to connect classroom science to the real world of science and technology. In other words, influencing students’ worldviews of industrialisation (embodied in science) will be an enabling motive for transforming the locally evolving industries through science and technology. However, the link or 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’ WOK, which according to Baker, Clay, and Fox (2002), are shaped by their socio-cultural environment. Studies in the 1970s and 80s documented different WOK and how what students bring to science classrooms, a product of their WOK, impacts classroom learning. These ideas have been referred to variously as children’s science or alternative frameworks (Driver, 1983), lay science (Furnham, 1992), plain common sense (Hills, 1989), naïve science (Nickerson, 1986). According to Hodson (1998), these ideas are formed in many ways including talking with others, interaction with media, visits to other settings such as zoos, museums, amusement parks, etc. Moreover, Hodson adds, everyday language use influences their understanding of phenomena experienced in life. There have been attempts to explain how these ideas are constructed. For instance, Cajete (1999) reveals how Native science as a way of life is derived from lived experiences and practice within Native communities. He adds: “Native life in community is a primal pathway to knowledge of relationship with the natural world”(p. 99) (see also Beck & Walters,1980). Other studies have been conducted among the Chinese, African American, etc., and most point to the fact that there are WOK that go beyond the traditional Western thought.

A study by Guerts (2002) has revealed pointers to the uniqueness of some of the ways Africans construct knowledge. She has challenged the commonly held assumption in the Western thought that “all humans possess identical sensory capabilities and that any cultural differences we might find would be inconsequential” (p.3). For example, one outcome of her ethnographic study of a community in Ghana, West Africa identifies bodily ways of gathering information as profoundly involved in society’s epistemology and the development of cultural identity. Similarly the work of Jegede (1995), Aikenhead (1996), and Aikenhead and Jegede (1999) in Canada and Africa show how cultural practices profoundly influence the way students *collaterally make sense* (hold multiple worldviews) of the world (see also Baker, Clay & Fox, 1996; Cobern & Aikenhead, 1998). For East Africans (EAs), Jua Kali an important part of their construct of cultural identity, and, hence, is a key locus to understanding EAs’ WOK.

¹ “Jua Kali” is a small-scale manufacturing and technology-based service sector (UNESCO/UNEVOC, 1998). 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.

² “As the country strives to attain the status of a newly industrialized country by the year 2020, it is imperative that the E&T [Education & Training] sector properly plays its role of developing the necessary human resource. For E & T to contribute meaningfully to industrialization as a basis for overall national development, the sector needs to fit within the public reform agenda” (MPET, 1998, p.v). (Commission for UNESCO, 2000).

To-date, there is no research done that considers high school students' WOK and related worldviews in the context of science activities that integrate classroom science and the science imbedded in the Jua Kali activities (real world). Yet there are compelling reasons for examining East African (EA) students' *Ways of Knowing* (WOK) through such contexts: 1) The study will provide understandings about how students see the world and harness these understandings to the service of developing better learning experiences; 2) Emergent research suggests that WOK are more than those implied in the traditional Western thought (Guerts, 2002) and, hence, examining EA students' WOK will enlighten our current understandings of how people make meaning of the world; 3) Many (about 3/4) East African school-leavers join Jua Kali every year (Maundu, 1997; McLeanand & Kamau, 1999; Kenya Commission for UNESCO, 2000; UNESCO/UNEVOC, 1998), and thus, understanding students' WOK will inform education programs that will support the East African countries' common vision of achieving industrialised nations status by 2020 (MPET, 1998); and 4). We strongly believe that recognising the relationship between classroom science and the science imbedded in the "Jua Kali" (real world) production activities, is one of the key ways to industrially revolutionalise this important EA sector. Thus, we see it as imperative that EA school-leavers see the links between classroom science and the real world embodied in the case of Jua Kali. Hence, this becomes one of the important precursors towards the evolution of local industrialisation to fulfill EA countries' 2020 vision.

OUR ON-GOING RESEARCH PROGRAM:

The interest in WOK stems, in part, from our (UBC team) (see our CVs – MRI) ongoing work on students' metacognition across learning contexts, which is revealing interesting insights into the role students' socio-cultural background plays in how they make sense of classroom and out-of-school experiences in Canada and Japan. For example, we found clear cultural differences in the way Japanese students verify their views with references to peer groups in specific ways the Canadian students do not (Hisasaka, Anderson, Nashon, & Yagi, 2005). Moreover, Dr. Anderson's work on long term memory demonstrates the critical influences of socio-cultural identities on perception (Anderson, 2003). In addition, Dr. Nashon's (2003) work on the nature of analogies that Kenyan teachers and students use in the teaching and learning of physics concepts revealed that the analogies were largely anthropomorphic and environmental – that is, culturally constructed (Nashon, 1003, 2004). A similar study, conducted in Nigeria, West Africa by Lagoke et al. (1997), revealed how biology instruction, which employed the use of environmental and anthropomorphic analogies, led to a reduction in the gender gulf in performance. In addition, Dr. Nashon's ongoing study in Uganda, which is examining students' conceptions of HIV/AIDS, shows that most students understand HIV/AIDS in anthropomorphic and environmental terms. These revelations coupled with an increasing presence of African students in our undergraduate and graduate programs at UBC, motivate us to seek SSHRC funding to develop a strong research program that would enrich our understanding of how other cultures make sense of the world. Moreover, these understandings will form part of UBC Teacher Education "Diversity" cohort that prepares elementary teachers in matters of diversity in Canadian classrooms.

SIGNIFICANCE OF THE STUDY:

This study is significant for teachers, students, teacher educators and the future economic and industrial development of East Africa. Hence, we see this study as assisting our attempt to understand EA students' WOK beyond the confines of the classroom - such as conceptual manifestations in the Jua Kali. We believe that understanding EA learners' WOK will provide new and enhanced theoretical understandings that will assist formal education to better connect with EA industry and assist in the evolution of EA economic development. The study will provide new insights into other WOK in cultural contexts beyond Western perspectives. Importantly, this research will assist teachers to bridge the divide that exists between classroom knowledge and local settings that have the strong potential to assist the learners to develop diverse more useful,

and relevant WOK. The hermeneutic perspective embodied in the methodology will also provide new theoretical understandings about how and under what conditions EA students change and develop their WOK. This will instrumentally inform educators and policy makers in EA to the service of the 2020 vision of attaining the status of industrialised nations.

THEORETICAL POSITION:

We come to this study with the following ontological and epistemological underpinnings: First, learning occurs holistically and not in isolated contexts (Ausubel, 1963) and a dynamic process developed through experiences that are interpreted in the light of the learners' prior knowledge (Driver, Leach, Millar, & Scott, 1997; Hodson, 1986, 1998; Jenkins, 1996; Kilbourn, 1998); Nashon & Anderson, 2004), attitudes, and personal background (Guerts, 2002; King, Chipman, & Cruz-Janzen, 1994; Lave & Wenger, 1991). Second, we take the view that learners' conceptions of science have direct impact on the ways in which they learn (Embeywa, 1986, 1987; Hodson, 1998). Third, the learners' worldviews are key to influencing their perceptions, interpretations of experience, and ultimately the conceptions of their reality (Hodson, 1998). Fourth, the socio-cultural identity of the individual and the group to which he/she belongs determines the cultural tools (WOK) that he/she uses to make sense of the world (Anderson, 2003; Bell, Lederman & Abd-El-Khalik, 2000, Nashon, 2003, 2004). According to King et al. (1994), through socialisation processes, learners "internalize the ways of the culture, to accept and affirm the values, traditions and attitudes of the broader society" (p.13). Fifth, we believe that, students' WOK rarely develop instantaneously, but rather, catalytic events that connect classroom science to the real world (similar to learning authentic science portrayed in Kilbourn's (1998) narrative on "Teaching Allison science") have the potential to gradually affect WOK over a period of time (Anderson et al., 2000). Sixth, we consider WOK as embellishing values and assumptions inherent in the development and interpretation of scientific knowledge (Bell, Lederman & Abd-El-Khalik, 2000; Kilbourn, 1998; Lederman, 1992; Lederman & Niess, 1997; Valerie, Abd-El-Khalick, & Lederman, 2000). Seventh, we also believe that although there are diverse WOK as implied by Bingle and Gaskell (1994), some of the WOK can propagate misconceptions. Lastly, we acknowledge the unique ways in which science differs from other ways of understanding and interpreting nature. This in essence, forms the background on which we have framed the proposed study seeking to investigate WOK among East African students.

METHODOLOGY

The study will employ an interpretive case study approach (Erickson, 1986; Gallagher & Tobin, 1991; Merriam, 1998; Stake, 1995; Yin, 2003). This methodology is appropriate for this type of investigation since 1) the methodology is congruous with our epistemological views of learning and WOK (see our "Theoretical Position", p.13); 2) we seek detailed thick description of learners' views and intimate understanding of their socio-cultural worlds.; and 3) the research questions of this study require a hermeneutic series of data gathering, analysis, and interpretation, each informing and shaping the next.

The case studies of students from selected schools will be representative of the main categories public high schools in Kenya. Our approach will be one where we qualitatively examine and describe the WOK of students emergent from their experience with an integrated classroom-Jua Kali science curriculum. Baseline interpretations of students' WOK will be captured in the pre-assessment of students' WOK using a specially developed questionnaire and interview protocol prior to any experiential interventions embodied within the classroom-Jua Kali science curriculum. Their WOK will be described in detail in a series of sub-studies where both the selected individual participant students and the groups (see specific procedure, page 15) to which they belong will constitute the units of analysis.

CHOICE OF SCHOOLS AND PARTICIPANTS:

This will involve six high schools representing the three main categories of public high school : two National, two Provincial and two District high schools³ (1 girls & 1 boys schools per category) will be selected to participate in the study. The study will involve Form 3 (grade 11) science students since Form 3 is the high school class (grade) when students select subjects to study for the Kenya Certificate of Secondary Education (KCSE) examinations taken at the end of Form 4 (grade 12). Therefore, better understanding of contextualized science, will motivate them to study it in Form 4 (last class in high school). Decisions about which students proceed to University/College in Kenya or end up in the Jua Kali centres are based on their performance in KCSE examinations. We use the EA students' experience of a classroom-Jua Kali science curriculum to elucidate their WOK. To gain an understanding of the cultural influences on students' WOK, it is prudent to select schools that are representative of the Kenyan school cultures – National (NS), Provincial (PS) and District (DS) schools. Most NS and PS schools are boarding while most DS are day (not boarding). This represents sub-cultures that have the possibility of exhibiting their own unique WOK. Many (90%) of the school leavers from District and 60% from National and Provincial schools do not go to post-secondary education (UNESCO/UNEVOC, 1998). Most of these students seek employment in the Jua Kali sector. For this reason, Form 3 students are our prime target group for investigation about their WOK since, as already stated, it is at this level that the students select the subjects to take for the national examination at the end of Form 4. Exposure to a classroom-Jua Kali integrated science curriculum in Form 3 is important in this study because it will allow us the opportunity to progressively monitor the students' developing WOK for 12 months of curriculum experience. The teachers selected to participate in the study will be those willing to prepare and implement the science curriculum in a way that integrates classroom-Jua Kali experiences. The integrated curriculum experiences will be co-developed by the CEACSWOK team and the participating teachers. This is aimed at sensitising the teachers to the power of using local contexts in teaching and promotion of fruitful learning (Anderson et al., 2000)

GENERAL PROCEDURES:

Form 3 science students from selected schools in Kenya will complete a specially developed questionnaire informed by Nott and Wellington's (1993) Nature of Science instrument, and tailored for this group of students and their local context. This will be complemented by one-on-one interviews (Anderson, 1990; Fontana & Frey, 1998) to generate descriptions of their baseline WOK and worldviews of science. Subsequently, this will inform the composition of groups in which key perspectives will be represented for the purpose of group engagement and discussion during and following classroom and Jua Kali-related learning activities and tasks. Additional data will come from reflective journals to be maintained by the students throughout the one year of experiencing an integrated classroom-Jua Kali science curriculum, face-to-face semi-structured interviews with the students and teachers, examination of instructional materials, student workbooks, and informal discussions with the workers at the Jua Kali centres. All the data sets will provide insights into students' transforming WOK 6 months later following the implementation of a science curriculum that utilizes Jua Kali-related

³ Kenya operates an 8-year primary, 4-year secondary and minimum 4-year university education system. Public secondary schools are stratified by their student catchment areas into National, Provincial, and District. Student selection to secondary schools is based on performance in the Kenya Certificate of Primary Education (KCPE) exams taken at the end of primary education. National schools select students from all regions of the country on a quota basis. These are top KCPE students who will likely go to university. Provincial and District schools respectively select their students from the provinces and districts where they are located. Most students are selected to these schools based on their performance in KCPE exams – best, above average and average performers join national, provincial, and district schools respectively.

experiences as catalysts for science knowledge construction. Moreover, the students' participation in the study will be in a way part of the experience of developing WOK.

SPECIFIC PROCEDURES:

From each of the six selected schools, which will include a boys' and a girls' school from each category, one Form 3 science class of about 40 students will be selected to participate in the study. Two groups will be identified from each class for the purpose of tracking and in-depth study to provide more detailed investigation and will constitute the student-level of analysis (Sn = 48; 8 students x 6 case classes). This will be subsequent to completing a specially developed baseline questionnaire, analysis of which will provide insights into students' WOK prior to experiencing a classroom-Jua Kali integrated science curriculum involving visits to local Jua Kali centres. The Venn diagram (Fig. 1) below illustrates CEACSWOK research activities.

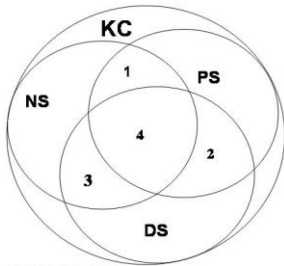
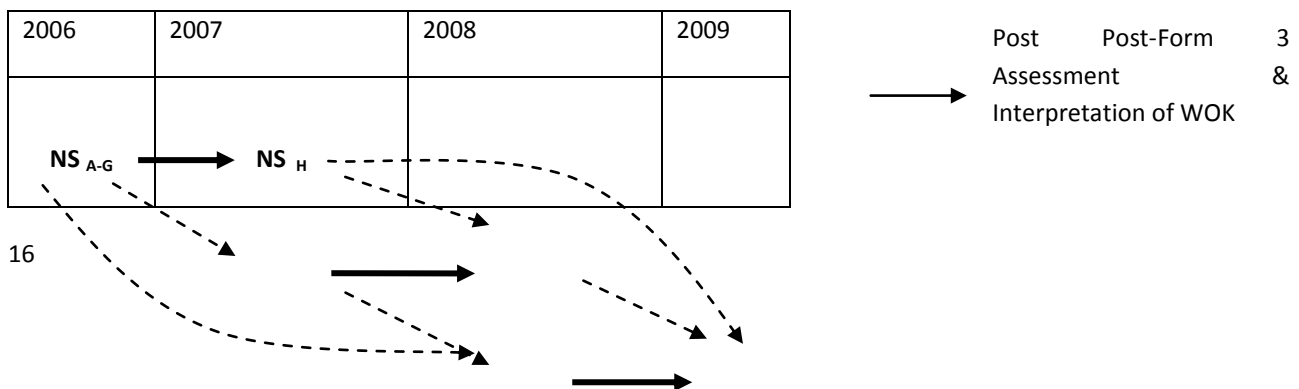


Fig. 1: Analyses
DS.

- A) The big circle represents the analysis of data from all the six schools to make claims emergent from data about the Kenyan context (KC). The three small circles represent the analysis of each sub-study (school type) to generate claims about WOK specific to each. The intersections represent comparative analyses that seek to discern emergent patterns about WOK specific to the sub-studies being compared.
- B) Intersections 1, 2, 3 and 4 represent common themes or claims about students' WOK emergent from the activities of the collaborative in NS and PS; PS and DS; and NS and DS.

The investigation will be undertaken over the course of a three-year period. In order to progressively monitor students' developing WOK, each student will maintain an ongoing reflective journal on any science concepts they might learn in subsequent units and how these relate to the real world of Jua Kali. Our local collaborator, Dr. Embeywa in conjunction with the classroom teachers, will on a regular basis collect student journals as a way of monitoring and tracking the progress as well as assisting teachers to naturalistically incorporate reflective journaling as part of their normal classroom practice. This is consistent with our theoretical position of non-instantaneous but gradual knowledge construction and development of WOK. Emergent patterns in participants' WOK will be discussed through bi-monthly teleconferencing with Dr. Embeywa and the collaborating teachers. The nature of the proposed study is that post Form 3 interviews and surveys will be administered 6-months into Form 4, a time when the students start preparing for national exams at the end of that year. The purpose of post Form 3 assessment of WOK is to find out how the classroom-Jua Kali integrated science curriculum enriched their way of seeing the world. The research process will be iterative so that revelations from preceding sub-study(ies) (by school type) will inform subsequent sub-studies as illustrated by Fig. 2 below.



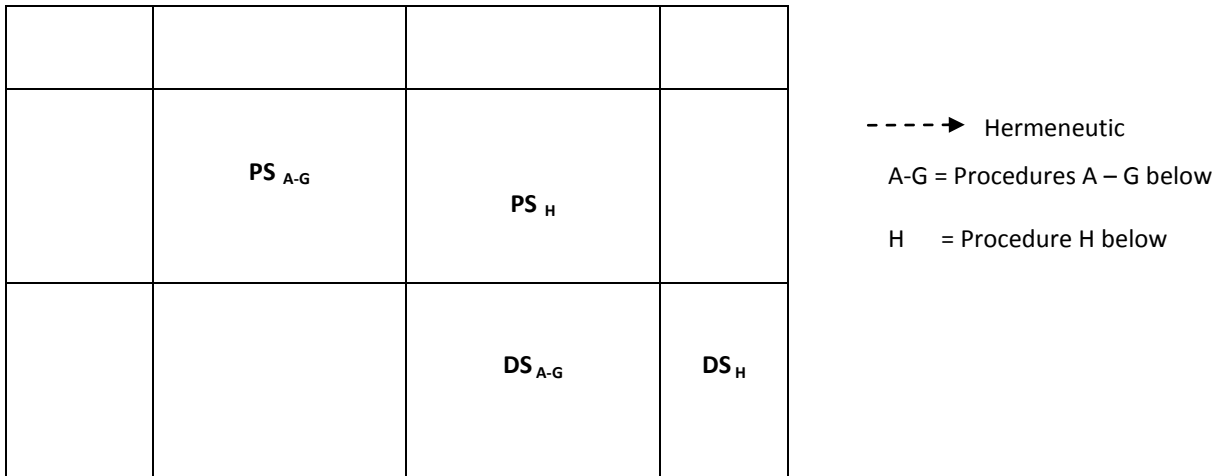


Fig. 2: Hermeneutic Representation

Participants in the subsequent sub-studies will be treated iteratively and similarly. Data collection in each case class will be as follows:

- (A) Elicit all students’ baseline WOK using a specially developed questionnaire;
- (B) In-class intervention designed to cue students about WOK and our role and goals as researchers and their role as participants;
- (C) Pre-intervention (pre-curriculum experiences) one-on-one interviews with case study students to further probe their WOK and more deeply elucidate and describe their baseline WOK;
- (D) Whole class curricular experiences including visits to a Jua Kali centre and engagement in tasks specially designed to evoke and engage their individual and corporate WOK;
- (E) In-curricular experience case data collection – Researcher field notes, recordings of in-situ conversations, and observation of the identified 8 case-students per class (selected on the basis of base-line WOK, informed analysis of in-curricular experience data, and teacher recommendations).
- (F) Student participation in classroom-based post-Jua Kali visit activities naturalistically integrated with the school-based curriculum; Student journaling of reflections of their experiences at the Jua Kali centres and following classroom-based activities;
- (G) Post-Jua Kali face-to-face semi-structured interviews with 8 case-students per class to probe the students’ WOK, and maintenance of reflection journals in which they record and reflect on how science concepts experienced in the intervening period between (D) and (H) and other out-of-school experiences related to their learning episodes.
- (H) Elicitation and interpretation of participants’ WOK using specially developed paper and pencil instrument and interview 6 months since experiencing 12 months of an integrated classroom-Jua Kali science curriculum.

The sub-studies will be sequential, initially considering NS in 2006, PS and follow-up on the NS in 2007, and DS and follow-up on PS in 2008 followed by a visit to UBC by Dr. Embeywa for a conference to review the progress of the study. The DS follow-up will be in 2009.

ANTICIPATED AND COMMUNICATION OF OUTCOMES

Anticipated outcomes: These include: 1) Students' better realisation and appreciation of Jua Kali centres as learning contexts; 2) Jua Kali production activities will be manifestations of classroom science and the realisation that science is better understood and appreciated in contexts; 3) East African teachers' and students' realisation that learning is holistic; and 4) New insights into the non-Western cultures' ways of understanding and knowing outside of Western perspectives;

Communication of outcomes: Presentations at, for example, the International Council of Associations for Science Education (ICASE), National Association for Research in Science Teaching (NARST), and the Canadian Society for the Study of Education (CSSE) annual conferences, and Kenya Science Congress; conducting seminars, workshops at local universities, curriculum development centre and the Kenya National Examinations Council; Publishing in scholarly journals such as International Journal of Science Education, Journal of Research in Science Teaching and African Symposia.

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