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Navigating Cultures and Epistemologies in Science and Technology Education

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NAVIGATING CULTURES AND EPISTEMOLOGIES

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This dissertation is dedicated to my children, Ashley Theresa, Landon John, Tucker Michael and Davis Matthew Kurz, for they will always be my delight and pride. Follow your dreams with hard work and anything is possible.

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ABSTRACT

Kurz, Kathleen T., Ph.D., University of Missouri – St. Louis, 2005. Navigating Cultures and Epistemologies in Science and Technology Education. Major Professors: William C. Kyle, Jr., Ph.D., Joseph L. Polman, Ph.D., Stephen A. Sherblom, Ed.D, and John G. Blake, Ph.D.

This investigation focuses on the nexus of science and culture in the lives of marginalized youth in the United States and South Africa. The epistemologies and contextual realities of cross-cultural learner cohorts and their understandings of scientific phenomena are examined. The researcher was a participant observer within the context of the Science, Technology & Culture: Empowering Learners (STC) program, an after-school and school-based collaboration focused upon integrating science, technology and culture. Electronic communication provided a vehicle for dialogue between youth in St. Louis, Missouri, USA and a South African Township.

Study findings include documentation of the marginalizing effects of poverty for the United States and South African study participants. Study participants drew upon multiple contexts to form identity. United States and South African learners revealed many ways of knowing as explanatory tools for natural phenomena. Learners maintained multiple epistemologies as explanatory tools after engaging in scientific pedagogical activities. However, belief in multiple epistemologies did not preclude learner trust in scientifically acceptable explanations for natural events. Change was a constant in the experience of study participants. Educators and learners negotiated their changing world through the lenses of their cultural/indigenous understandings. Implications for policy and practice are provided.

Chapter One

Introduction

This study focuses on the nexus of science and culture in the lives of disadvantaged youth in the United States and South Africa. The epistemologies and contextual realities of cross-cultural learner cohorts and their understandings of scientific phenomena are examined. The different ways of knowing about scientific phenomena and making sense of the world are formed within the embedded cultural contexts of learner's homes, schools, communities and countries. The teaching and learning of science dwells in the interaction between the various ways knowledge is generated within and among people and their experiences with social structures such as schooling.

Theoretical Foundation

The critical theory of Jurgen Habermas (1972) delineates three epistemological scientific categories and corresponding human cognitive interests. A specific human cognitive interest generates knowledge in each of Habermas' scientific categories. "The approach of the empirical-analytical sciences incorporates a technical cognitive interest, that of the hermeneutic-interpretive sciences incorporates a practical one, and the critically-oriented sciences incorporates an emancipatory cognitive interest" (Kyle, Abell, Roth & Gallagher, 1992, p.1015). The cognitive interest prescribes the method of deriving knowledge and the type of knowledge derived (see Table 1).

Table 1

Habermas' (1972) Theory of Knowledge Constitutive Interests

Interest	**Knowledge**	**Science**
Technical	Instrumental (causal explanations)	Empirical-analytic natural sciences
Practical	Practical (understanding)	Hermeneutic or interpretive sciences
Emancipatory	Emancipatory (reflection)	Critical sciences

Note. From "Emancipatory Interests: A Reply to French," by W.C. Kyle, Jr., S.K. Abell, W.M. Roth and J.J. Gallagher, 1995, *Journal of Research in Science Teaching,* 32, p.887. Copyright 1995 by the National Association for Research in Science Teaching. Reprinted with permission of the author.

The critical theory of Habermas (1972) is applied to science education as the theoretical foundation for the study. The three epistemological categories and corresponding cognitive interests can be applied to the teaching and learning of science. Habermas' (1972) model can function as a cognitive schematic organizer for science educators who maintain the goal of the incorporating each of the cognitive interests in science education. The science content knowledge of schooling is often based on technical causal explanations for natural phenomena agreed upon by the current community of scientists. Using the canons and concepts of science as an explanatory framework for comprehending the world requires humans to understand from within and apply scientific knowledge in practical ways. An education in science can also foster critical agency in learners by providing opportunities for critical reflection and practical action during the process of schooling. Kyle (in press) supports the inclusion of Habermas' emancipatory cognitive interest in science education; "With an emphasis on imagination and critical reflection, rather than cultural reproduction and transmission of knowledge, science education may facilitate the emancipatory interests of students".

Empirical-Analytic Sciences and the Technical Cognitive Interest

Empirical-analytic science is frequently cited as the model for natural science. Logical positivism serves as an illuminating paradigm for the empirical-analytic approach to science and scientific knowledge. Logical Positivism was the dominant framework for science in the first half of the twentieth century (Bechtel, 1988). Scientific knowledge is extrinsic in the positivist view. Knowledge is based on observations and is viewed as independent from human beings' thoughts about it. Hollis (1994) places the empirical-analytic, positivist view of science under the realm of explanation. Basic beliefs can only be formed from human perception directed by experimentation and experience with the world.

Habermas' technical cognitive interest is exercised in the process of controlling and predicting natural phenomena in the empirical-analytic sciences. Cause-effect linkages of natural events constitute facts. Scientific rigor, external and internal validity, reliability and objectivity are paramount to the logical positivist. Values and ethics are not acknowledged. Positivism requires scientists to be highly trained in technical and quantitative procedures. The scientist is viewed as a disinterested observer who is not privy to procedures of policy and decision-makers. Kerlinger (1964) voices support for an empirical-analytic, positivist, technical view of science by stating the basic intent and nature of scientific research is the controlled and objective study of relations among phenomena. Essential components of this approach are precise scientific language, scientific hypotheses, variables, constructs and mathematical foundations.

Herein, I submit a picture of the teaching and learning of science comported under each of Habermas' (1972) epistemological categories. Conducting the teaching and learning of science from Habermas' empirical-analytic category would require pedagogy to be knowledge driven. Scientific facts about the world would be imprinted on the mind of the learner. Learners would develop skill in the utilization of the scientific method that is characterized by the steps of hypothesis, materials, procedure, data/results and conclusion. Learners would spend much time composing 'if, then' statements, making predictions, controlling variables and organizing data. The above activities fulfill Habermas' technical cognitive interest, but do not address the collaborative, argumentative and creative components of science as articulated by Bronowski (1956/1965).

Hermeneutic-Interpretive Sciences and the Practical Cognitive Interest

Habermas' second category of science is hermeneutic or interpretive science. A hermeneutic-interpretive scientific view acknowledges that scientific inquiry is a human activity. "The actions in which members of the scientific community engage – observation and experimentation, measurement and concept formation, theory construction and testing and so forth – are subject to certain rules, norms, standards, and the like" (McCarthy, 1978, p. 66). The generation of scientific knowledge is built upon the communication structures of scientists. Scientific discourse and progress occurs within the framework of shared meanings, norms and values.

The human cognitive interest in the hermeneutic-interpretive sciences is a practical one. The practical cognitive interest rests on the meaning and understanding individuals place on information, rather than the objectivity of the knowledge. Humans are believed to attach meaning and understanding to knowledge from a vertical orientation based on their own life histories and from a horizontal orientation based on social interaction with other human beings (McCarthy, 1978).

Hollis (1994) terms this orientation the realm of understanding. Knowledge is derived from the beliefs of human beings. Knowledge building is intrinsic. The direction of fit is mind to world rather than world to mind. Humans attempt to make sense of the occurrences of the world via the use of symbols. Vygotsky names symbols such as language, mathematical representations and graphics as cultural tools (Kozulin, 1998). Cultural tools are psychological utensils employed by humans during interactions with individuals and the world outside of the self to build knowledge that is consequently internalized (Vygotsky, 1981). In Hollis' (1994) understanding realm, scientific judgments are allowed to include elements of human interpretation. A meaningful order of knowledge includes human intersubjectivity and human understanding from within.

I propose that conducting the teaching and learning of science with the additional dimensions of Habermas' practical cognitive interest and human interpretation of scientific knowledge, is an agent driven, rather than a knowledge driven approach. The learner is not viewed as a tabula rasa or blank slate. Science principles may be derived from empirical-analytic methods, but understanding them is bound up with the interpretation of the learner. The learner's preliminary ideas and explanations about the natural world are taken into account. Learner's preliminary ideas often differ from scientifically acceptable principles. Instructional activities are related to student ideas and discrepancies between those ideas and currently accepted science principles. Authentic inquiry, experimentation and classroom discourse help learners reconstruct or generate new conceptual frameworks.

Critical Sciences and the Emancipatory Cognitive Interest

Hollis (1994) raises the issue of the place of ethics in the natural sciences in his discussion of facts and values. This vantage point is useful for exploring Habermas' third category of knowledge, critical sciences, and its implications for the teaching and learning of science. Hollis notes the 'Pugwash' conference attended by a group of eminent scientists, including Albert Einstein and Bertrand Russell. "The conference rejected the cosy view that scientists are merely technicians who discover means to authorized ends" (Hollis, 1994, p. 205). Such a view acknowledges that knowledge is power and scientists and educators may bear ethical responsibility regarding the discovery and dissemination of knowledge.

Habermas' third category of science, critical sciences, involves humans engaging in critical reflection. Critical reflection provides a form of knowledge that can be used to develop and change human culture. The human cognitive interest in the critical sciences is emancipatory. The emancipatory cognitive interest expresses the human desire for freedom from dogma and puts knowledge at the use of the people for the purpose of release from institutional or environmental forces that limit rational control over their lives.

I advocate conducting the teaching and learning of science to include Habermas' (1972) emancipatory cognitive interest. This requires an expanded view of knowledge and consideration for the socially embedded process of knowledge formation as explicated by Kyle (in press). Teachers facilitate learners to respond autonomously to what they have been taught under an emancipatory posture. The following statement from Habermas' inaugural lecture at Frankfurt University illustrates the power of such an approach: "In self-reflection knowledge for the sake of knowledge attains congruence with the interest in autonomy and responsibility" (McCarthy, 1978, p. 89).

Exploring Habermas' emancipatory cognitive interest in the teaching and learning of science requires science educators to expand the operational definition of the nature of science and the meaning of the term 'education' as it relates to science. Kyle's work in science education in developing countries contributes to such a discourse. Kyle acknowledges that learning in science includes constructing conceptual understandings of the world. This knowledge construction typically has technical and practical components. However, Kyle proposes, "The totality of an education in science is equally as much oriented toward social justice, critical democracy, empowerment, action-taking, and investing in our future's intellectual capacity as it is about constructing conceptual understanding of the world" (Kyle, 1999, p. 255).

The ontology of an emancipatory goal for science education requires the realization that the search for scientific knowledge is dynamic, not static. Learning is connected to the lived experiences of learners and their roles as agents in an ever-changing world. In his work in developing countries and the indigenous knowledge systems of their citizens, Kyle posits a need to "put knowledge at the service of the people" (Kyle, 1999, p. 6). This requires science education goals that ask questions relating to the needs and life world experiences of learners. The study of the science of ecology as an exemplar illustrates the capacity for emancipatory and meaningful application for learners. Learners can conceptualize many of the scientific principles of ecology using technical and practical methods, but must engage in critical reflection to evaluate scientific or political stances regarding environmental issues.

Science education can incorporate each and all of Habermas' cognitive interests. Habermas' technical cognitive interest is explored via the scientific method that attempts to be an objective, value-free search for knowledge. Scientists have discovered many causal relationships in the fields of physics, biology and chemistry. Educators who incorporate Habermas' practical cognitive interest acknowledge the humanity that ties the observer with the physical phenomena to be manipulated and observed. Scientific knowledge as a human creation is considered in the planning of teaching and learning activities. Habermas' emancipatory cognitive interest includes self-reflection on the parts of the teachers and the learners. Creativity, argumentation and debate are valued as hallmarks of scientific progress (Bronowski, 1956/1965). Students learn to understand science as a fallible, human activity that is continually evolving. Scientific literacy becomes a goal so students and teachers may reflect upon, critique and engage in action-taking in the context of their lived experiences.

However, I caution that the emancipatory interest of learners is developed and exercised by the individual. Proficiency in school-based science learning is the first level of success for learners and an important element of the exercise of science education with empirical, hermeneutic and critical components. Critical reflection and practical action are not bestowed upon learners with pre-determined social outcomes under my proposition to incorporate each of Habermas' cognitive interests in the teaching and learning of science. Rather, learners are introduced to the idea that "Science is not a mechanism but a human progress, and not a set of findings but the search for them" (Bronowski, 1956/1965, p.63). Just as scientific discovery reveals the complexities and beauties of the natural world, the complexity and beauty of the minds of individual learners is to be respected and not directed to predetermined social outcomes.

Literature Overview

Epistemological issues in science education arise from questions concerning knowledge legitimization. Apple (1993) posits that knowledge is legitimized via a dominant hegemonic machine run by working parts of cultural, economic and political power. Many bureaucratized urban school systems are accused by Apple of teaching knowledge not linked to the daily lives, histories and cultures of students. Educators are encouraged to reflect on questions such as: "Whose knowledge is taught? Why is it taught in this particular way to this particular group?" (Apple, 1993, p. 41). Circulating knowledge is commensurate with distributing power.

Educators sharing these views often adopt a critical theory of knowledge production and dissemination and strive to acknowledge the social and political situatedness of the production of hegemonic and subordinate knowledge systems (Aikenhead, 1997; Barton & Osborne, 2001; Kyle, 2001; Leistyna & Sherblom, 1996). Educational structures are viewed as vehicles for cultural transmission from one generation to the next. Knowledge, ideas, norms, values and beliefs associated with the dominant culture are the cargo of this cultural transmission. Learners who are members of nondominant cultural groups can be marginalized from mainstream educational practice.

Liberatory Pedagogy

Critical science education spawns liberatory pedagogical practices. Science for all reform efforts are linked to students, teachers and community members participating in the production of scientific knowledge driven by contextualized learning needs. Liberatory pedagogical practices are applicable to all learners, but are often conducted with and for marginalized groups of science education such as girls, children in poverty, and ethnic, racial and language minority children.

Pedagogy has emerged from the contexts and experiences of poor urban youth (Fusco, 2001; Simmons, Ruffin, Polman, Kirkendall & Baumann, 2003; St. Louis, Burkett & Barton, 2001). Interdisciplinary and science projects were conducted based on problems, questions and ideas emanating from learners and their life worlds. In their work with children in homeless shelters, St. Louis et al. (2001) found authentic learning occurred when they honored children's desire to use science class to make things that were useful in their lives. Fusco (2001) worked with homeless urban teenagers designing and implementing a community-based science project and assessment. The students transformed an empty city lot into a usable garden and gathering spot for the community. An historical narrative documents the young people producing science in the service of their community. Fusco questions current school science education by sharing a comment of one of her students, "I thought it was gonna be like a project, like in school, you know like a fake project" (p. 221). Simmons et al. (2003) fostered student scientific and mathematical inquiry through an investigation of the history of a local cemetery. These educators sought to broaden the definition of science for teachers, students, parents and community members.

Fostering students toward scientific literacy within a current and relevant context falls into the realm of liberatory pedagogy as students are guided to analyze and evaluate claims. Project based activities (Polman, 1998), role-play (Odegaard & Kyle, 2000) and imaginative writing (Hildebrand, 2001) have all been employed in this process. Preservice and inservice teachers (Barker, 2001; Howes, 2001) engage in experience, reflection and dialogue in order to forge a fit between the role of instructional leader and the canons of science. Liberatory pedagogy allows students and teachers to evaluate the norms and methods of science, clarify cognitive scientific knowledge and display attitudes regarding organized science.

Cultural Border Crossing

Navigating among the canons and concepts of science requires learners to negotiate many cultural borders (Aikenhead, 1997). These borders are between and among everyday experiences, the canons of science, dominant and subordinate cultures, home, school, neighborhood and community surrounds. The congruence or lack of congruence between the various embedded contexts of the learner may enhance or impede learning. This may occur in the learning experiences of non-Western students and marginalized Western students.

Members of nondominant cultural groups attempting to learn Western science may experience a complex process of connecting their worldview and ways of understanding scientific phenomena with the canons and understandings of Western science. The destruction of indigenous culture as an expense of assimilation into the canons of an academic discipline is not a desirable outcome (Aikenhead, 1997; Ogawa, 1995; Snively & Corsiglia, 2001; Stanley & Brickhouse, 1994). Indigenous peoples have distinctive ways of knowing about scientific phenomena and its effect on their existence. Educators are charged to include all learners as active agents and producers of knowledge rather than mere consumers of predetermined facts. Understanding the nexus of science and culture and negotiating a path toward meaningful learning is a paramount challenge for science educators.

During their work with students and educators in Africa, Kyle (1999), Jegede and Aikenhead (1993) and Ogunniyi (1988) examine the nexus of science and the African world-view. Ogunniyi (1988) attempts to discern a useful point of contact between Western science and African culture. Although Western science and African worldview are both attempts to explain natural events, they are based on different conceptual paradigms. Ogunniyi (1988) asserts that Western science is founded on a mechanistic focus and the African worldview rests on an anthropomorphic picture of the world. Although he opposes an assimilation model for African students into the culture of Western science, Ogunniyi posits the possibility of successful accommodation of both cultures for students and teachers. Jegede and Aikenhead (1993) do not disavow entire assimilation into the canons of Western science for Africans in the cases of students who express a desire for and have potential to become scientists. For other students, various forms of parallel or collateral learning and acculturation are deemed possible. Thus, agreement exists among science educators that multiple knowledges exist. Kyle (1999) advances the notion of the futility of status assessments of different forms of knowledge in light of the pressing nature of ensuring sustainable development worldwide. Cooperatively and collaboratively constructing useful knowledges between cultural groups is advocated as a tool in the pursuit of meeting human needs and sustaining the environment.

Implications for Educational Research

If science educators build a foundation on a critical theoretical epistemological base, followed by liberatory pedagogical practices serving as a framework for teaching and learning and acknowledge the existence of multiple ways of knowing, what are the implications for research in science education? In a survey of science education research literature, Rudolph (2002) concludes that the abundance of research is technical in nature. Common research topics are in categories such as conceptual change phenomena or efficacy of instructional innovation. However Rudolph notes, “Much of this work proceeds apace with little reflection on the more philosophical questions regarding the ultimate goals for which these conceptual tools and instructional techniques are being developed” (p. 1). Rudolph implores science educators to reflect on the functional role of science education in society. It is concluded that science educators should attempt to reach consensus on what social function an education in science should serve, rather than continuing discord regarding the meaning of scientific inquiry and the nature of science.

Kyle (1999) addresses the issue of what social function an education in science should serve from a critical theory epistemology and liberatory pedagogical stance. An education in science is advocated as a useful tool for human empowerment and action taking. Implications for research in science education include conducting research in real educational settings, attending to sociocultural and political contexts of schooling, including classroom teachers as collaborators in research, and ensuring the inclusion of marginalized students in science education action research projects (Kyle, 1991).

Kelly and Duschl (2002) reviewed theoretical and empirical studies of epistemological issues in science education. In concordance with Kyle's recommendation to conduct research in real educational settings, Kelly and Duschl suggest epistemological studies in science education consider "the situated, everyday practices that define science and knowledge in educational and other settings" (p. 19). They enumerate current studies regarding inclusive classroom discourse that allows alternative genres of talk, the relationship of writing to inquiry, and ethnographic approaches to examining scientific discourse within the norms of a community of learners. In a discussion of critical theory and liberatory pedagogy in science education, Kelly and Duschl (2002) review research about cultural border crossing by students, indigenous knowledge systems and knowledge legitimization in education. They submit that despite the type of research programs in execution, emerging research issues collect around the fields of emphasis on the role of language, dialogue, and dialectics in learning and constructing knowledge, the social basis of knowing in science and the focus on epistemic practices. These emerging research issues have the potential to edify a critical theoretical epistemology and liberatory pedagogy for science education because they involve the examination of the role of language in individual learning and forming community discourse norms. Such examination has the potential to foster critical thinking regarding community discourse norms as inclusive or alienating for learners, discovering multiple cultures of science and legitimization of different ways of knowing.

Research Context

The Science, Technology & Culture: Empowering Learners (STC) project is an after-school and school-based collaboration focused upon integrating science, technology and culture. This program is for youth in low-income communities. Electronic communication provides a vehicle for dialogue between youth in St. Louis, Missouri, United States of America and youth in Nairobi, Kenya and Durban, South Africa. The program is a collaborative effort between the University of Missouri – St. Louis, community social service centers and neighborhood schools in St. Louis, Kenyatta University (Kenya), and University of KwaZulu-Natal (South Africa). The goals of the program are to bring technology and associated skills to students in underserved, low-income communities, build scientific literacy for students, expand ways of knowing and facilitate cultural exchange between United States and Sub-Sahara African students. Participation in the after school program aimed at middle level students is voluntary and parental or legal guardian written permission is required for entrance into the program. The STC program is a web-based curriculum with pedagogical activities designed to build technological skills, scientific literacy and cultural exchange. Lesson plans, links to instructional aids and learner artifacts are posted on the website at http://stc.umsl.edu. Learner artifacts that are posted on the program website include PowerPoint presentations, working documents from hands-on scientific investigations, digital photographs, digital movies and geographic information systems (GIS) projects. See Appendix A for sample curriculum and technology competencies.

The school-based STC venue is a middle school located in a low-income community abutting the city of St. Louis, Missouri. The middle school learners participate in the STC curriculum as part of a middle school science and technology course. The African cohort students participate during the school day and range from upper primary to early secondary grades. The researcher is a STC instructor involved with overall planning of the program, supervising program instructors, teaching students and developing curriculum. The researcher also functions as the facilitator for South African schools participating in STC. The study is focused on the learners in the United States and South Africa.

Standards

Science curriculum in the United States emanates from the National Science Education Standards (NSES). Curriculum and accountability elements for science education at the national, state and local levels are derived from the NSES. The national standards contain the traditional content areas and associated concepts in physical science, earth and space science and life science to be learned in the context of scientific inquiry, technological tools, science in personal and social perspectives and the history and nature of science (National Research Council [NRC], 1996).

The National Curriculum Statement of the Republic of South Africa organizes the natural sciences learning area under four knowledge strands: life and living, energy and change, planet earth and beyond, and matter and materials. The statement advocates the promotion of learning science while promoting understanding of science as a human activity, the history of science, the relationship between the natural sciences and other domains, the contribution of science to social justice and societal development, responsibility to self, society and the environment and the ethical consequences of decisions (South Africa Department of Education, 2002).

The standards documents of both countries are founded on the goal of the development of scientific literacy for citizens defined in the United State document as follows:

> Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity (NRC, 1996, p. 22).

The Natural Sciences Learning Area of the South African document deals with the promotion of scientific literacy as follows:

- the development and use of science process skills in a variety of settings;
- the development and application of scientific knowledge and understanding; and
- appreciation of the relationships and responsibilities between science, society and the environment. (South Africa Department of Education, 2002, p. 4)

The teaching and learning of science in the United States and South Africa is influenced by national standards documents. The unique setting of the STC program affords a view into the role of cultural/indigenous knowledge in developing scientific literacy, building conceptual knowledge and discoursing with cross-continental cohorts.

Marginalization

Disparities between society's haves and have-nots regarding technological access are soundly documented (Civille, 1995; Cummings & Kraut, 2002; Kahin, 1995; Keller, 1995). The Internet is becoming a chief vehicle for accessing information. However, universal service for citizens is not being realized. Rules of a market-based economy are marginalizing low-income people from the route of technological progression. Household income is an adequate predictor of home computer ownership and racial and ethnic groups do not have commensurate use of home computers. The United States Census Bureau (2001) estimated that among United States citizens approximately 72.3 percent of Asian/Pacific Islander individuals live in households with computers contrasted to 60.9 percent of White, 37.3 percent of Black, and 40.0 percent of Hispanic individuals.

The United States and African students participating in STC are marginalized from their larger societies by poverty and disenfranchised in terms of access to technology and the corresponding access to knowledge that technology affords. The STC curriculum facilitates students communicating electronically in various formats about self, identity, culture and scientific understandings. The theoretical foundation for the planning of STC activities incorporates each and all of Habermas' cognitive interests, liberatory pedagogy and cultural border crossing.

Identity and Culture

In his critique of rational choice theory, Bruner (1990) posits that in the process of building identity humans incorporate values from relationships within a cultural community. Values and corresponding ways of life become part of self-identity and serve as functional units within communities. Identity of self involves a reciprocal relationship between "the outside in as well as from the inside out, from culture to mind as well as from mind to culture" (p. 108). The relationship between identity and culture has implications for cognition and intercultural situations. Intercultural differences and differences between out of school and in school cultures can be manifested in cognition. Kozulin's (1998) discussion of Vygotsky points out that different cultures have different psychological tools such as signs, symbols and language that are employed for thinking and communication. Polman (2004) illustrates the potential for after-school programs to combat the effect of deficit orientations students may receive in school. The cultural experiences of adolescents influence identity, cognition and behavior.

Research Questions

Participation in the Science, Technology & Culture: Empowering Learners experience affords learners the opportunity to negotiate a myriad of cultural borders such as between and among everyday experiences, the canons of science, dominant and subordinate cultures and indigenous/cultural knowledge while engaging in discourse with a cross-continental cohort. The journey to scientific literacy addressed in science education standards is bound up in the embedded understandings of students.

Electronic communication between cross-continental cohorts and digital artifacts produced as part of the STC curriculum provide a lens into learner cognition that has high fidelity and authenticity. Functioning as a participant researcher affords the opportunities to study learner artifacts and interact with learners in order to gain knowledge about how learners form scientific understandings of the world, the relationship between cultural/indigenous knowledge, everyday science and content learning goals and the effect on cognition of discourse with a cross-continental cohort.

Given the unique embedded understandings of students participating in the STC program, and the technological facilitation of cross-cultural discourse, the primary research question guiding the study is:

What are the cultural/indigenous understandings of the STC participants during the technologically facilitated scientific and cultural learning experience?

The pursuant secondary research questions were used to focus the investigation and target data that would illuminate the primary research question.

What are the perspectives and beliefs of the South African educators involved in the STC learning experience?

What various ways of knowing about scientific phenomena are expressed by participants?

What changes in thinking and ways of knowing occur over time as learners engage in cross-cultural scientific pedagogy and discourse?

Anticipated Importance of Findings

Findings will contribute to the discourse of science education pertaining to the importance of determining and including students' prelimary cognitive schemas in the teaching and learning process. Prior knowledge is formed by interactions with the physical world and with other people. These interactions are embedded within a social, political and cultural context. STC experiences have potential benefits for students living with United States and African perspectives. United States students will examine and express African ways of knowing and African students can potentially build scaffolds between indigenous science and Western science. Findings from an analysis of cross-cultural discourse will reveal evidence of such learner forays into different ways of knowing.

Science and health issues such as the AIDS pandemic, sustainable development and environmental preservation are global in nature. Electronic communication and meaningful contextualized learning experiences can enhance cross-cultural understanding of such issues. Study findings can give insight into the cognition of poor, marginalized students and the relationship between ways of knowing and cultural context. Findings can determine evidence of bridge building and meaning-making between students of different cultures that will be required in any global approach to problem solving.

Sub-Saharan African and United States students participating in the STC program have similar contextual realities. Both groups of students reside in high poverty areas within their respective communities and both have been disenfranchised from dominant educational, health, technological and political processes. An analysis of cross-cultural discourse can potentially reveal the ways computers can facilitate communication and inter-cultural understanding and contribute to empowerment in different ways. Findings can document how equity in terms of access to knowledge and information via computers helps marginalized people obtain a voice.

Preview of Chapters Two Through Five

Chapter Two contains a review of literature regarding cultural border crossing in science education, explication of epistemologies and differentiated learning outcomes, relevant science and practical action, and standards.

Chapter Three delineates the methodology of the study. The appropriateness of the utilization of a sociocultural paradigm and naturalistic inquiry for the investigation is explained. Information includes a description of the study setting, definition of terms, list of study delimitations and limitations, description of sample, and methodological tools and vantage points used for gathering data. The STC pedagogical activities under study are aligned with United States and South African science education national standards.

Chapter Four provides results and an analysis of the data. The data is interpreted, coded, analyzed and synthesized into emergent themes relevant to the primary and pursuant research questions. Emergent themes are explicated on a continuum from providing relevant details to painting a wholistic picture of the phenomenon under study.

Chapter Five discusses the research findings in relationship to the literature of the field. Conclusions of the study are explicated. Implications and recommendations pursuant to the study conclusions are tendered. Research findings are placed within a larger context and suggestions for further research are provided.

Chapter Two

A Review of the Literature

Science education researchers seek to understand the processes and conditions of the notion of learners crossing borders into the canons of science. Researchers seek to explicate the multiple epistemologies negotiated by learners and the associated learning outcomes. Science educators grapple with the purposes an education in science should serve. Science teachers and learners are held accountable within a standards-based educational system. Thus, there are many influences on the learner during the process of schooling in science.

Cultural Border Crossing

Many explications of the learner's process of navigating among the canons and concepts of science within a cultural context provide insight into the notion of cultural border crossing. Aikenhead (1997) proposes that science is a "subculture of Western culture" (p. 220) and that First Nations students of Canada must not come to understand Western science at the expense of losing their traditional Aboriginal knowledge. He puts forth a process model in pursuit of the goal of learners incorporating Aboriginal culture, scientific knowledge and technological skill as they develop into effective citizens. Three main processes are identified: Enculturation – learning Aboriginal "knowledge, values and skills" (p. 230), Autonomous acculturation – "Everyday thinking is an integrated combination of commonsense thinking and some science/technology thinking" (p. 230), and Anthropological instruction: learner moves between epistemologies of the subculture of science and everyday thinking and does not often see a connection between the two. Aikenhead proposes a cross-cultural science education in which teachers serve as tour guides for learners in order to facilitate understanding and movement between and among indigenous knowledge and Western science. However, Aikenhead and Jegede (1999) acknowledge, “Holistic or multiple-world outlooks do not determine the effectiveness of cultural border crossing into school science” (p. 284). The possibility of a simple analysis is disavowed.

Ogunniyi (1988) agrees that “science is largely a product of western culture” (p. 5) and is often incongruent with African traditional knowledge. He describes cultural borders between the alleged public nature of the norms, standards and values of Western science and the secrecy and religious and magical nature of African cosmology. African traditional knowledge is explained as having an anthropomorphic substratum versus the mechanistic orientation of Western science. Inconsistencies and merits are acknowledged between both epistemologies. Traditional African knowledge is deemed logical, inquiry based and valid within its system, but “the scientific world view has been found to be more effective in predicting and controlling natural phenomena than any other thought system” (p. 5). Ogunniyi asserts that border crossing, bridge-building and meaning-making is possible between the two thought systems.

Jegede (1997) also addresses the cultural border crossing necessary between African traditional thought and Western science. Demarcations between the epistemologies include the anthropomorphic nature of African traditional knowledge and the mechanistic nature of Western science, the authority of the African tribal elder as the unchallenged purveyor of truth and the debatable nature of Western science, and the communal versus individual orientations of African and Western learning. He advocates attendance to the sociocultural factors of learning in order to help learners negotiate between traditional knowledge and the knowledge base of school science. Five predictors of “sociocultural influences on the learning and teaching of science in Nigeria” (p. 9) are presented resulting from research investigations: Authoritarianism, Goal Structure, Traditional Worldview, Societal Expectation and Sacredness of Science. Jegede expresses the goal of the integration of African learners into a changing global community while working with traditional knowledges.

Examples of cultural border crossing in Asia are offered by Ogawa (1995). Science is deemed as one way of understanding phenomena and every culture is determined to have its science. Ogawa substitutes the idea of multiscience for border crossing. The multiscience perspective includes working with learner beliefs within the arenas of personal science, indigenous science and Western modern science. Ogawa makes the distinction between indigenous science and personal science by considering indigenous science community knowledge held by a group of people and personal science individual understanding developed as a result of interaction with the environment and other people. However, similar to previous recommendations, Ogawa advocates teachers "plan to activate the interaction and communication among students for them to understand their personal sciences and indigenous sciences as well as Western modern science simultaneously" (p. 590).

Snively and Corsiglia (2001) explain a subset of indigenous science dubbed traditional ecological knowledge (TEK). Traditional ecological knowledge of indigenous peoples of Canada and other countries includes environmental understanding and practices to foster ecological sustainability. The authors urge that prior knowledge of children of all cultures is important to the teaching and learning process and encourage teachers to facilitate border crossings for learners between the Western scientific ways of knowing and the ideas, beliefs and values of non-Western cultures.

Grappling with the conception of the nature of science as the ultimate universalistic account of natural phenomena is advocated by Stanley and Brickhouse (1994). The United States national science education reform agenda includes pedagogy about the nature of science.

The authors contend that such pedagogy should “reflect a multicultural perspective on scientific knowledge” (p. 387). Pointing to some who do not believe that indigenous knowledge systems should be understood as science, Stanley and Brickhouse argue for curriculum reform to include multiple ways of knowing. However, they concede the dominance of Western science in the United States and support providing U.S. learners with a solid comprehension of Western scientific tradition and the ability to participate in the current discourses pertinent to modern scientific, technological and societal issues.

Solomon (2003) and Costa (2004) examined cultural border crossing between home and school. Noting that research has failed to find a clear relationship between outside of school science activities and school science achievement, Solomon studied a British project that documented learners’ interactions with parents when performing simple science activities. Findings illustrate variations in attitudes and ideas from home that influence border crossing from home to school. A significant finding was that learners made original contributions to scientific investigations at home, but rarely in the school setting. Learners were also not comfortable discussing school science at home. Thus, the home-school border crossing was difficult. Costa studied the degree of congruency between United States learners’ venues of family, friends, school and science. High school students were interviewed about their “perceptions of school and science, the importance and influence of friends on these perceptions, and family conditions that were significant to their lives” (p. 313). It was found that learners planning careers in science displayed a high congruency between the worlds of family, friends, schooling and science. Students with low or discordant congruencies were academically challenged in school science. School practices that attempt integration of the learners’ various worlds were endorsed.

Hodson (1993) and Lee, Fradd and Sutman (1995) consider the role of language as a psychological and cultural tool in the teaching and learning of science. Noting the different vantage points and experiences of learners from different cultural groups, Hodson cautions that teaching and learning methods may not be universally appropriate for all cultural groups. Hodson elucidates the various functions of language in the teaching and learning of science as follows:

> In the context of multicultural science education, there are several aspects to the "language problem": diversity of mother tongue, the language of science (specialized terminology, use of everyday words in specific, restricted contexts, and style of written communication), the stylized language of classroom interaction in general, and the use of language-based activities to bring about learning. (p. 691)

Recommendations include paying special attention to learners whose first language is not English, patience with learners regarding the use of the terminology of science, and including cultural differences in language during language-based learning activities. However, Hodson recognizes that the terminology of science can also be problematic for English as first language learners.

Lee, Fradd and Sutman (1995) studied science knowledge, science vocabulary and cognitive strategy use of a diverse group of ethnolinguistic learners. Learners of monolingual English Caucasian, African-American, bilingual Spanish and bilingual Haitian Creole orientations displayed distinct patterns of scientific knowledge, vocabulary and cognitive strategy use. Terms used in science teaching and learning such as sink and float had different meanings in the different languages. Recommendations include helping students from non-mainstream monolingual English Caucasian backgrounds negotiate the cultural borders of science by acknowledging and including differences in discourse patterns, word-meanings and strategy use.

Ogunniyi, Jegede, Ogawa, Yandila and Oladele (1995) and Brand and Glasson (2004) investigated the cultural border crossings of science educators. The worldviews of science teachers in Botswana, Indonesia, Japan, Nigeria and the Philippines were examined by Ogunniyi, et al. The science teachers of these non-western cultures were found to have the same worldview presuppositions. The teachers held monistic traditional worldviews with an ontology that reality is one unitary organic whole with no independent parts. Conversely, the teachers taught more narrow, mechanistic ideas in science class. The authors identify their findings as mere baseline data and suggest additional study about implications of the data for science education curriculum and practice. Brand and Glasson conducted an ethnographic study targeting racial and ethnic identities of preservice teachers in the process of crossing cultural borders into science teaching. The ethnic identities of the Asian American, African American and Rural Appalachian preservice teachers were firmly entrenched. Findings implicated that the preservice teachers' ethnic encapsulation affected their beliefs about student diversity and science teaching. The researchers advocate for teacher education programs that provide preservice teachers with reflective activities regarding their cultural identities and beliefs about the nature of science and the associated possible implications for dealing with diversity in the science classroom.

Pomeroy (1994) reviewed cross-cultural studies in science education literature and determined nine research agendas regarding cultural border crossing: (1) science and engineering career projects; (2) an indigenous social issues context for science content; (3) culturally sensitive instructional strategies; (4) historical non-Western role models; (5) demystifying stereotype images of science; (6) science communication for language minorities; (7) indigenous content for science to explain; (8) compare and bridge students' worldviews and the worldview of science; and (9) explore the content and the epistemology of both Western and Aboriginal knowledge of the physical world. The research agendas reside on a loose continuum from firm categorical cultural distinctions to critical analysis of epistemologies and "access to alternative views and methods" (p. 68).

Jegede and Aikenhead (1999) surmise that the science education community is "travelling towards two destinations: understanding concept learning and developing science-for-all programmes" (p. 46). The authors deem that the achievement of science-for-all agendas across the globe will require culturally sensitive curriculum and practices in science education. Crossing cultural borders in order to participate in the modes of scientific discourse can be problematic for all learners regardless of cultural orientation (Aikenhead & Jegede, 1999; Hawkins & Pea, 1987; Osborne & Freyberg, 1985; Snively & Corsiglia, 1987). Hawkins and Pea (1987) posit that learners develop knowledge structures through cultural and environmental interactions and that deep understanding in science must occur in a dynamic, complex, sociocultural process that incorporates these knowledge structures. According to Snively and Corsiglia (1987), commonsense understandings of Western learners and cultural knowledge of non-Western learners can both serve as impediments in the journey toward scientific literacy. Aikenhead and Jegede (1991) submit, "Students' flexibility, playfulness, and feelings of ease in the world of science will help determine the smoothness with which students cross the border into the culture of science" (p. 274). Citing worldwide research on children's ideas in science, Osborne and Freyberg (1985) assert "unless we know what children think and why they think that way, we have little chance of making any impact with our teaching no matter how skillfully we proceed" (p. 13). In simpler and broader appellations than worldview, cultural knowledge, traditional knowledge or indigenous knowledge, Osborne and Freyberg contend, “It is the similarities and differences between children’s science and scientists’ science that are of central importance in the teaching and learning of science” (p. 13). The plethora of cultural border crossing research in science education is an attempt to define, explicate and determine pedagogical implications pertinent to these similarities and differences.

Explicating Epistemologies and Differentiated Learning Outcomes

The nature of knowledge and different ways of knowing provides inquiry venues for researchers in science education. The congruence or lack of congruence between the various embedded contexts of the learner and the associated enhancement or impediment to science learning outcomes is mapped in the research literature.

Explicating Epistemologies.

Osborne and Freyberg (1985) conducted an extensive research project about the ideas learners bring to school and the impact science teaching has on those ideas. They examined how children make sense of their everyday world through the cultural lenses of experiences, interactions with others and the use of language as a cognitive tool. Findings included that children’s ideas were influenced in various ways by the science teaching and learning process. The interpretation of events and learning experiences through a cultural lens also spurred the work of Ogunniyi (1988) in his studies of science and the traditional African worldview. Ogunniyi characterizes the African worldview as metaphysical as opposed to the presentation of Western science in African schools as impersonal. The individual African is believed to hold a monistic-vitalistic worldview in which one is seen as an integrated part of the world and not a separate observer. The world is viewed as one organic whole with no independent parts. Life processes are understood holistically and cannot simply be explained by the laws of physics and chemistry. Ogunniyi uses the example of the concept of causality, "the cause of a disease which may be quite acceptable to a scientist may not be so to an African since misfortune is normally attributable to the diabolical motives of enemies" (p. 3). Ogunniyi makes a major distinction between the reliance of Western science on a mechanistic explanatory model and the African worldview reliance on an anthropomorphic explanatory model. A mechanistic model supports the understanding of living and non-living things as merely different variations of physico-chemical occurrences. The African anthropomorphic model resides on the belief that people are not independent from the physical and natural world and events have spiritual and physical sources. Citing the need for African science teachers to develop a "scientifically valid view of the word" (p. 5), Ogunniyi refers to his research in Nigeria (Ogunniyi 1984) about compatibility of the two thought systems. Findings are enumerated that include that traditional worldviews of the Nigerians contained many scientifically valid views of the universe and people. The participants simultaneously held scientific as well as traditional views of the world "perhaps in the same way in which certain scientists in the West hold the scientific and the Christian world view" (p. 6). Thus, Ogunniyi concludes that although there are conflicts between traditional and scientific worldviews, they are workable and resolvable by carefully designed science literacy programs. Science is advocated as a tool to help traditional people meet challenges without replacing traditional culture.

In a dialogue pertaining to indigenous knowledge systems and science and technology education, Onwu and Mosimege (2004) point out the conundrum of including indigenous and scientific knowledge systems in teaching and learning and assigning status to both ways of knowing. The authors pose the problematic juxtaposition of the two knowledge systems as "competing or complimentary worldviews" (p. 1). They advocate the development of a synergy in the classroom between the two knowledge systems that provides stimulation and support for learner conceptual restructuring. The dialogue illuminated other possible discordant areas between indigenous knowledge systems and science. Inquiry, debate, discussion and questioning are the hallmarks of science. Questioning knowledge claims is not a component of indigenous knowledge systems. Thus, indigenous knowledge is somewhat static and handed down from generation to generation. Scientific knowledge is dynamic and always changing. Indigenous knowledge systems organize thought in a holistic fashion and spiritual causes and effects of natural phenomena are accepted. Western science precludes spiritual variables. Onwu and Mosimege (2004) admonish against the establishment of one knowledge system as more relevant than the other, but instead urge that educators situate the learning of science in the sociocultural environment of the learner.

Jegede (1997) summarizes his findings from a series of studies about culture and science education in Nigeria in a list that corresponds to findings of other researchers:

African Mode of Thought:

- Anthropomorphic
- Monistic-vitalistic and metaphysical
- Based on cosmology interwoven with traditional religion
- Orally communicated
- The elder's repository of knowledge is truth not to be challenged
- Learning is a communal activity

Western Science:

- Mechanistic, exact and hypothesis-driven
- Seeks empirical laws, principles, generalisation and theories

- Public property, divorced from religion
- Primarily documented via print
- Truth is tentative and challengeable by all
- Learning is an individual enterprise (p. 7)

Jegede (1993) explains in detail the five identified areas of sociocultural influence on the teaching and learning of science for Nigerian learners:

- Authoritarianism – locus of authority in classroom same as traditional society where "science teacher is seen as the elder who knows all" (p. 8) and not to be questioned
- Goal Structure - "interactive pattern among the people of Africa which is predominantly of the cooperative kind" (p. 8) in opposition to individual competition in school
- Traditional Worldview – "traditional beliefs and superstitions being used as framework through which occurrences are interpreted" (p. 8)
- Societal Expectation – individual behavior and achievement defined in context of "nature of interaction within a communal society" (p. 8)
- Sacredness of Science – study of science is viewed as special, out of the ordinary, strange and beyond the conceptual frameworks of non-Western people

The five sociocultural variables described above form the basis for the Socio-Cultural Environment Scale (SCES) developed by Jegede and Okebukola (1990). The 30-item Likert type instrument was developed to "measure the socio-cultural environment of science classrooms in a non-western society" (p. 3). The stated intent of development of the instrument was to gather empirical data regarding socio-cultural influences in science classrooms that could inform teaching and learning.

In their research of South African learners' views of the universe, Lemmer, Lemmer and Smit (2003) describe three paradigms that can be used to make sense of the natural world:

> The world as an organism, as perceived by ancient Greek philosophers such as Aristotle. The world as a mechanism; a view that emerged with Newtonian mechanics. The world as a pattern of numbers: the contemporary world of Physics. (p. 563)

In an empirical study of the ideas about the universe of South African first-year physics students, it was found "a statistically significant larger number of African than European students have organistic models of the universe" (p. 563). A literature survey revealed the ancient Greeks and small children also held organistic worldviews. The authors regard the organistic worldview of the African learners as more natural and prevalent in the African culture. The researchers note the inclusion of the study of 'the planet earth and beyond' present in the new South Africa science curriculum. They conclude that for learners to understand mechanistic and physics based science in school, a paradigm shift may be necessary. Learners would need to see the study of physics as one way to understand the natural world.

The role of indigenous languages as psychological and cultural tools employed for making sense of the world was examined by Thomson (2003). Kenya's Rift Valley is noted for the ecological value of its fauna and flora. The language of the Keiyo people of the Rift Valley is solely oral and not documented in writing. Thomson interviewed or gave questionnaires to Keiyo elders and students regarding indigenous names for snakes and narratives about snakes that illustrated indigenous scientific knowledge. Findings include the Keiyo names for snakes are " based on colour, behaviour, their observed diet and/or their habitats, such as a tree species" (p. 99). The Keiyo narratives about snakes revealed information about ecological roles, human uses, potential dangers and venom treatments. For example, the lethal puff adder's Keiyo name is *Kipirimut* meaning count to five referring to the number of steps an individual may successfully complete after being bitten. The aggressive, dangerous red spitting cobra's Keiyo name is *Pep/Peta* meaning straight as an arrow referring to the cobra's behavior of spitting deadly venom straight into the eyes of humans and causing blindness. Another theme of the narratives was the placement of snakes in mythical settings in order to teach "Keiyo ethical and moral values" (p. 99). Thomson challenges Kenyan educators to "develop relevant formal curriculum and instruction in languages that promote, and are sensitive to, contextual learning reflecting Kenya's rich heritage in bio- and cultural diversity" (p. 110). The documentation of indigenous science knowledge in order to inform teaching and learning is advocated for other contexts around the globe.

All members of the science education community do not endorse researching, revealing and including other ways of knowing. It is argued that modern work in the natural sciences is performed all over the world by scientists of multiple cultures who "agree on the rules of the game called science" (Good, 1995, p. 335). Current scientific knowledge is viewed as accurate, universal and sufficient and, thus, it is not necessary to add indigenous ways of knowing into the curriculum (Good, 1995; Loving, 1995; Wolpert, 1993). In addition, Dzama and Osborne (1999) conducted a study concerning poor academic science performance of students in Africa. The investigators reviewed literature pertaining to traditional cultures and the teaching and learning of science. An empirical study on a specific group of learners in Malawi suggested "poor performance in science among students in developing countries in Africa is caused by absence of vocational incentives rather than by conflict between science and African traditional values and beliefs" (p. 387). The researchers conclude the African worldview is mechanistic, pluralistic and anthropomorphic. The flexibility of the worldview is deemed sufficient to incorporate learning science. The researchers conclude poor academic science performance among learners in developing countries "is not due to the worldviews of students in these countries but to the absence of supportive environment for serious science learning where science features significantly in the popular culture" (p. 401). Thus, although differences in cultural contexts and learner epistemologies are acknowledged as bona fide, the importance of the relationship between explicated epistemologies and learners' understanding science is under contention.

Differentiated Learning Outcomes.

Science education researchers have investigated possible differentiated learning outcomes emanating from the multiplicity of learner epistemologies. Jegede and his colleagues have amassed a body of work pertaining to the relationship between sociocultural variables and science classroom outcomes, including the process skill of observation (Jegede, 1991), learner's study of science and associated gender effects (Jegede and Okebukola, 1989; Jegede and Okebukola, 1992), effects of a sociocultural teaching mode on learner attitudes and achievement (Jegede and Okebukola, 1991), eco-cultural factors influencing learning (Okebukola and Jegede, 1990), attitudes and effects of computer use (Jegede, Okebukola and Ajewole, 1991), wait-time (Jegede and Olajide,1995) and teacher ranking of science standards (Jegede and Okebukola, 1996). The findings of these studies illustrate the existence of a relationship between sociocultural factors and learner understanding of school-based science.

Jegede (1991) examined the science process skill of observation citing its central role in the scientific study of natural phenomena. The study was grounded in the assumption that "observational skills can be influenced by students' belief in traditional African cosmology, beliefs and superstitions" (p. 37). A sample of 319 pre-degree science students of a Nigerian university completed the Traditional Cosmology Test (TCT) developed and validated by Ogunniyi (1987). The instrument consisted of nine case studies followed by possible explanatory statements designed to measure respondent belief in traditional cosmology, superstitions and taboos. A Test of Observational Skills (TOS) was developed and validated to assess scientific observation. The TOS consisted of observational tasks of zoological and botanical items common in the study of basic biology such as external morphology of the rabbit and phototropic response in the shoot of a potted maize plant. Five of the ten observational tasks dealt with flora or fauna associated with traditional beliefs and five of the flora and fauna tasks had no association with traditional beliefs. For example, traditional belief holds that rabbits are reincarnated forms of ancestors and should not be seen in daylight and the sighting of a chameleon portends an ominous event. "The results indicate that students with low level of belief in African traditional cosmology scored significantly higher than those with high level of belief in the five tasks that have traditional belief associated with them" (p. 43). Although Jegede allows that causality is not inferred and a rigorous control was absent in the study, students who "exhibited a high level of belief in African traditional cosmology made significantly fewer correct scientific observations of biological structures and processes when compared with those with a low level of belief" (p. 43). Jegede recommends modeling African science curriculum in order to use the pre-existing conceptual frameworks learners bring into the classroom to help them construct knowledge.

Jegede and Okebukola (1989) applied their developed instrument, the Socio-Cultural Environment Scale (SCES), to a sample of 707 Nigerian secondary biology, chemistry and physics students. Student levels of Authoritarianism, Goal Structure, African Worldview, Societal Expectations and Sacredness of Science were assessed. The learner responses about Authoritarianism indicated that the cultural respect for African elders corresponded to the belief that the teacher held all the answers. Under Goal Structure, the learners thought co-operative group work had a positive effect on science learning. Regarding African Worldview, most learners held that traditional beliefs hindered learning science and only students with educated parents do well in science. The evidence that science was viewed as a special endeavor and held in prestige by society revealed the Societal Expectation factor. Sacredness of Science was manifested in learner opinions that “science concepts have magical explanations, studying science requires special intelligence, science concepts conflict with what they believe and that only above average Africans should aspire to be scientists” (p. 145). A summary of findings showed the sociocultural factors of Authoritarianism, African Worldview, Societal Expectation and Sacredness of Science had a negative effect on learners’ study of science. However, Goal Structure had a positive effect. Implications include the researchers’ endorsement of the SCES scale for further use in Nigeria and other non-Western cultures and an encouragement for science teachers to use co-operative interaction among learners and attempt to mitigate negative effects of sociocultural factors on learning.

In a further analysis of the data, Jegede and Okebukola (1992) compared sex differences recorded on the SCES girded by the knowledge that girls do not achieve as well as boys in science academics. Results for the SCES illustrated boys secured “higher mean scores in the subscale of authoritarianism, the girls had higher mean scores in the subscales of goal structure, African worldview, societal expectation, and sacredness of science” (p. 640). Data from the societal expectation subscale illustrated that girls perceived low societal expectation for their success in science and low personal expectation for a career in science compared to boys. Jegede and Okebukola make two major implications from the study results. The first is the society must prioritize more access for girls to science-related careers and funnel that priority down to school science expectations for girls. The second is a call for further qualitative-interpretive study to explain and illuminate the findings.

Okebukola and Jegede (1990) also found that the reasoning patterns and sociocultural preferences of students had an effect on conceptual understanding in science. Students with magical/superstitious reasoning patterns did not achieve as well on the Science Concept Test as students who used empirical reasoning. Students who expressed preference for cooperative learning versus competitive or individual work also performed better on the science concept instrument. In addition, "students from authoritarian homes achieved less well than … those from permissive homes" (p.667). Okebukola and Jegede call for science education curriculum and pedagogy that is linked to the sociocultural environment of the learners.

Jegede and Okebukola (1991) measured change in learner attitudes and achievement after an intervening treatment to mitigate sociocultural hindrances to science learning. It was found that when the teacher of the experimental group facilitated evaluation of traditional beliefs in relationship to the biology concepts of the lessons, learners developed more positive attitudes about science and better science achievement than the control group. The authors contend that participating in a socio-cultural mode for learning will provide insight for students about the construction of knowledge.

The introduction of a new psychological and cognitive tool, the computer, into a sociocultural environment was examined by Jegede, Okebukola and Ajewole (1991). Microcomputers were introduced in a Nigerian biology secondary class. After using the computer, the subjects displayed a significant positive attitude change toward the use of computers to learn biology. The researchers caution that the novelty of the relatively new technology and the dazzle of the new software may have contributed significantly to the post-treatment positive attitude of the subjects. The students working in cooperative learning groups reported the highest computer use attitude scores after treatment. The authors point out that based on that finding, the expense of introducing microcomputers in developing countries could be reduced if learners work in cooperative groups. Citing the presence of previous findings in the literature that students learn more effectively at computers, Jegede et al. found "no difference in achievement profiles of students taught using the computer" (p. 705) versus the control group. The researchers submit that students from technologically impoverished contexts may undergo a period of adjustment to new psychological and cultural tools before real gains in academic achievement occur.

Jegede and Olajide (1995) point out the need for complementary cross-cultural information in science education in their study of wait-time, classroom discourse and sociocultural factors in Nigeria. The researchers establish that findings from studies in the West have determined positive effects of sufficient wait-time between teacher scaffolding and learner verbalization during classroom discourse. Although study data showed that the average first wait-time for Nigerian teachers was 3 seconds, deemed sufficient for the United States, "the amount of student participation in classroom discourse was very low and influenced by authoritarianism" (p. 246). The researchers propose that English, a second language for the learners, is the official language for schooling in Nigeria and longer wait-times may be necessary for second language teaching and learning. In addition, wait-time "was shown to have a strong relationship with the sociocultural factors of authoritarianism, goal structure, societal expectation and traditional cosmology" (p. 246). The researchers summarize:

> On one hand, there is the students' view of the teacher as an elder whose authoritarian ideas are not to be challenged. On the other, there is the teacher's ideas about students' learning being a passive activity carried out by very ignorant minds who should be seen

only and not heard. Both of these stem from the traditional non-Western environment of Nigeria and relate wait-time to sociocultural factors. (p. 246)

Jegede and Olajide reflect on the possible irony of Nigerian science teachers conducting classes in an inquiry mode while embedded in authoritarian social mores. Further examination and discourse regarding this situation is recommended.

In another study of teacher orientation, Jegede and Okebukola (1996) learned how postsecondary school science education students ranked science education program standards. The students ranked in priority order thirteen program standards of the Science Education Program Assessment Model. The standard of encouraging students to be self-directed learners was ranked as first priority, followed by integrating appropriate concepts, processes, values and skills of other disciplines into science as second and including experiences which foster group interactions as third. Providing information about careers and vocations in various areas of science, integrating physical and biologic sciences with special emphasis on environment and recognizing the growth characteristics of students were ranked 11th, 12th and last priority respectively. The authors conclude the priority ranking of developing self-directed learners is in line with Nigerian National Policy on Education. Jegede and Okebukola propose that third ranked fostering group interactions reflects traditional African culture. Recommendations call for further study about the match between professed priorities and educational practice of Nigerian science teachers.

On a broader scale, education researchers have developed categorical models for understanding learning outcomes (Costa, 1995; Gilbert, Osborne and Fensham, 1982; Jegede, 1995; Phelan, Davidson, & Yu, 1993). Efficacious border crossings between school and home are deemed important for successful schooling by Phelan, Davidson, and Yu (1993). They identify four patterns of this border crossing. Congruent Worlds/Smooth Transitions identifies the presence of common sociocultural characteristics between home, peers and school that facilitate smooth transitions between the contexts. Different Worlds/Boundary Crossings Managed signifies differences between home, peers and school contexts that are effectively negotiated by learners. Different Worlds/Boundary Crossings Hazardous refers to differences between home, peers and school contexts that are negotiated hazardously and not as effectively by learners as in categories one and two. Borders Impenetrable/Boundary Crossings Insurmountable identifies norms, values, beliefs and knowledge systems as highly incongruent between home, peers and school contexts. Thus, these learners are resistant to negotiating multiple worlds.

Costa (1995) applied the multiple worlds border crossing paradigm in a science education research venue. High school science students were interviewed about their perceptions of school, science and the influence of family and friends. The purposes of the research were to determine a "model for understanding how students' responses to science are related to the degree of congruency between their worlds of family and friends and the worlds of school and science" (p. 314) and to consider the practical implications of the model. Five categories emerged regarding students' family and friends and success in school and science:

- Potential Scientists: Worlds of family and friends are congruent with worlds of both school and science.
- "Other Smart Kids": Worlds of family and friends are congruent with world of school but inconsistent with world of science.
- "I Don't Know" Students: Worlds of family and friends are inconsistent with worlds of both school and science.
- Outsiders: Worlds of family and friends are discordant with worlds of both school and science.

- Inside Outsiders: Worlds of family and friends are irreconcilable with world of school, but are potentially compatible with world of science. (p. 316)

Costa builds on the multiple worlds paradigm by separating school and science success while maintaining the model of a continuum between congruency and discordance between sociocultural contexts and schooling. She recommends that science curriculum be related to the impact of science on the lives of students and for professional development for teachers pertaining to at-risk students and cultural diversity.

Jegede's (1995) categorical model for understanding learning outcomes is the collateral learning theory described as a way "to explain how non-Western learners attempt to cope with science learning within a classroom environment not very receptive to their indigenous knowledge" (p. 98). Jegede's model contains four types of collateral learning on a continuum of progression through meaningful learning. He acknowledges the presence of similar collateral learning in every society, but the theory is based "upon my research experience of almost two decades centred upon socio-cultural factors and science learning in non-Western environments" (p. 98). The term collateral learning represents constructed knowledge concerning a science concept held side-by-side, without conflict, in a learner's cognitive schema. Jegede gives the example of scientific versus African ideas about the natural phenomenon of the rainbow. In science class, learners are exposed to the scientific explanation of the rainbow as a refracted beam of light by droplets of water. African traditional thought views the rainbow as a python crossing a river or a premonition of the passing of a chief. The learner potentially holds the scientific reason or cause for the occurrence of the rainbow along with traditional thought about the significance of the rainbow. Jegede's four types of collateral learning are explained below:

- Parallel collateral learning – Learner's pre-existing cognitive schema remains unchanged and new concept is held in schema in parallel fashion, without interaction between the two frameworks.

- Simultaneous collateral learning – Learner expands cognitive schema while simultaneously learning indigenous knowledge and scientific knowledge. Learner may compare and contrast ideas from the two different worldviews.

- Dependent collateral learning – Learner modifies existing cognitive schema after assessing conflicts between two worldviews.

- Secured collateral learning – Learner develops new conception in long-term memory after resolution of cognitive conflict between indigenous knowledge base and school science.

Jegede advocates providing guiding progression for students from parallel, simultaneous and dependent learning to the goal of secured collateral learning. Research about the relationship between the collateral learning theory and specific learning outcomes is encouraged. Aikenhead and Jegede (1999) expand the application of the theory of collateral learning to any cognitive conflicts, in Western or non-Western venues, originating from cultural dissonance. The authors position the collateral learning theory as a cognitive explanation for the process of cultural border crossing.

Jegede's collateral learning theory has some similarities to the work in science education research of Gilbert, Osborne and Fensham (1982) during the Learning in Science Project in New Zealand. The authors describe a range of possible outcomes from teacher-learner interaction on the preliminary ideas children bring into the science classroom.

- Undisturbed children's science outcome – Learner's pre-existing cognitive schema remains unchanged after teaching and learning activities.

- Two-perspective outcome – Learner holds two parallel viewpoints. One schema is used for school science and the different schema is used for everyday life. Often the two viewpoints are unrelated in the learner's mind.
- Reinforced outcome – Ideas taught are unintentionally misinterpreted as lending support to learner's pre-existing cognitive schema.

- Confused outcome – Learner looses confidence in preconceptions without better conceptions being constructed.

- Unified scientific outcome – Learner builds coherent scientific acceptable schema and are able to make better sense of their world by restructuring their ideas in useful ways. Learners are enabled to make better sense of their world by restructuring their ideas in useful ways.

Jegede's (1999) parallel collateral learning and the two-perspective learning outcome describe the same condition of the learner holding multiple cognitive schemas in parallel fashion. Secured collateral learning and unified science outcome involve the learner successfully negotiating between different epistemologies and developing acceptable explanations for natural phenomena.

The categorical models for understanding learner outcomes proffered by Costa (1995), Gilbert et al. (1982), Jegede (1995) and Phelan et al. (1993) include aspects of the ability of learners to carry complimentary and contradictory theories. These intersections or juxtapositions of cognitive schema can take on diverse configurations according to the proposed models. However, although the various learner outcome models are described on a continuum, they are based on the premise that the cognitive schema learners bring to science class must be altered, matured and sophisticated. Teachers are to guide learners through the process of changing original ideas into more scientifically correct views. This paradigm is restrictive and does not consider the possibility that learners may be able to hold multiple epistemologies efficaciously.

Discussing his extensive work in science education in Africa, C. Malcolm (personal communication, June 4, 2004) refutes the label of epistemological border crossing citing the permeable nature of the borders of multiples ways of knowing and the ability of people to hold complementary and contradictory ideas simultaneously. In addition, although Western science is often described as having a mechanistic orientation, Malcolm is remindful of the frameworks for the study of the sciences of biology and ecology that are built upon multiple data perspectives, consensus making and model building. Cause and effect relationships and predictions in the disciplines of biology and ecology are multi-faceted and interpretation fuels the construction of scientific theories. Kyle (1999) concurs that "Ecology is an interdisciplinary science that considers the interconnectedness of many phenomena previously considered independent" (p. 2-3). Noting the existence of localized indigenous knowledge, Kyle (1999) sites a potential for links between ecological conceptions and local indigenous knowledge systems that can be helpful and emancipatory for citizens. Thus, the term navigating epistemologies may be more suitable that border crossing for describing the cognitive journey undertaken by learners when they experience the precepts of the scientifically acceptable theories of their day. Malcolm endorses the goal of advancing understanding for learners, similar to Kyle's (1999) image of cooperatively and collaboratively building useful knowledges between cultural groups.

Learning outcomes models about the process of learners negotiating multiple epistemologies support the theory of constructivist learning. Ausubel (1968) professed one of the basic tenets of constructivism, "The most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly" (p. iv). Science education literature explicates multiple epistemologies learners must negotiate in order to learn science. However, what are the implications of the conflicts and congruencies in these epistemologies? Is it incumbent upon science educators to adjust science content goals for schooling in order to include indigenous science knowledge and multiple ways of knowing? Does the nature of science need to be renegotiated by all stakeholders? Or, does the existence of multiple epistemologies simply provide better, more refined information for educators to use in the development of more useful, meaningful, effective, integrative and constructive pedagogical practices?

Relevant Science and Practical Action

An education in science has the potential to be a useful tool for human empowerment and action taking (Aikenhead, 1997; Gruenewald, 2003; Hodson, 1993; Kyle, 1999; Malcolm & Keane, 2004). In a practical action orientation for science education, commensurate with the progression of science, learners are presented "a world that is being made – it is changing constantly – thus, for this very reason, it can be changed, it can be transformed, and it can be reinvented" (Kyle, 1999, p. 6). In their work providing relevant science for a rural community in South Africa, Malcolm and Keane (2004) "took the position that science education, appropriately defined, can contribute deeply to rural communities, not only practically, but in strengthening democracy and promoting equity" (p. 10). The community members deemed science learning relevant if it addressed the serious conditions stemming from poverty in the community such as hunger, cold and illness. The children's schooling was encompassed in a community science and technology endeavor to obtain information and begin a chicken farming/egg production enterprise as a step toward addressing community needs. Such relevant science activities produce useful knowledge and afford practical action. However, "the challenge for relevant science education is to move back and forth between details of context and profound abstraction" (Malcolm & Keane, 2004, p. 21). Science educators are required to be expert 'scaffolders' in order to aid relevant science participants in making the conceptual links between everyday practice and scientifically acceptable theories.

Science as a tool for human empowerment and action taking is the foundation for a discussion of the moniker 'transformative action research' by Malcolm, Gopal, Keane and Kyle (in press) in a further description of work in two communities in rural KwaZulu-Natal Province in South Africa. Community generated definitions of relevant science that helped mitigate the effects of poverty differed from the current science education content of South African schooling. The authors endorse purposes for research linked with researchers actively participating in transforming the human condition and affecting social policy rather than merely reflecting upon pre-planned action taken.

Aikenhead (1997) interprets practical ends for science education for First Nations peoples as "working at a job; preparing for a career (including a scientific or technical career); making a decision about a science-related societal or personal issue; or making sense of one's community or nation increasingly influenced by Western science and technology" (p. 218). He also points out the ironic possibility of science hindering, rather than facilitating, practical solutions in his description of the work of Medvitz (1985). United States millwrights of the 19th century were self-taught and unschooled in the science of hydrodynamics. Water mills were developed according to the effectiveness of the product with no reliance on scientific principles. French engineers were required to design watermills based on 19th century knowledge of hydrodynamics, which constrained the process. Aikenhead endorses knowledge for practical action situated in multiple ways of knowing.

Gruenewald (2003) names such practical action a critical pedagogy of place. A critical pedagogy of place involves the nexus of environment, culture and education. Learners assess what needs to be transformed and what needs to be conserved. Hodson (1993) discusses the role of science education in promoting responsible and active citizenship as a vehicle for raising questions of "interests and values, both within and between societies, majority vs. minority interests, aspirations and expectations of different cultural and ethnic groups, matters of international concern, third-world issues, and so on" (p. 685). Although curriculum statements frequently advocate for relevant science, the realization in practice is often difficult. Grade 7

Ethiopian primary school teachers reported their assessments of relevance and appropriateness about the chemistry content for their students of average age 13. Enigda (2002) points out the Ethiopian education reforms advocating “curricula relevant to the day to day life of the learners” (p. 941). The content for grade 7 includes topics such as important chemical industries in Ethiopia, physical and chemical changes, atomic theory and oxidation and reduction. The teachers reported very low levels of relevance and appropriateness for their learners in the curriculum and pedagogical materials. Ethiopia is an agrarian country and teachers reported lack of links to this everyday context for learners. For example, an understanding of the role of chemical industries in “agricultural production, horticulture and cottage industries, etc., could have make our grade 7 chemistry more relevant” (p. 945). Enigda recommends phenomena in the learner’s everyday environment, such as the chemistry of traditional medicine and plants used locally as detergents, be used for a beginning understanding of chemistry. Also, “these phenomena should be discussed at the macro level” (p. 950), rather than in the abstractions of chemical formulas.

The recent research studies of Turner and Font (2003) and Stears, Malcolm and Kowlas (2003) are examples of critical pedagogy of place and relevant science. Turner and Font worked with 6th grade students in Harlem in New York City on a research project promoting critical mathematical agency. This agency is defined as learners drawing on “mathematical understanding to investigate situations, engage in social critique, and act transformatively upon conditions in their lives” (p. 5). Learners negotiated an emergent mathematical curriculum by posing problems in the school that needed to be addressed. Overcrowding at their middle school was analyzed mathematically by ‘The Space’ project. Learners formulated questions, collected data and constructed arguments about the school space issues using mathematical concepts including measurement, perimeter, area, ratios, computing mixed numbers and fractions and converting metric and standard units. It was found that in the course of the project, learners discovered and used mathematics as a discipline that helped them access cultural and social power.

In order to make school science relevant, prior everyday knowledge and interests of learners must be revealed and used in planning teaching and learning activities. Working in Grade 5 classes in Townships and informal settlements outside of Cape Town, South Africa, Stears, Malcolm and Kowlas (2003) interviewed learners about topics of interest for science learning. Learners expressed interest in fire, cooking, repairing things, animals and medicinal uses of plants. The topics were relevant to the everyday lives of learners living in poverty with frequent fire hazards in informal settlements and common duties such as cooking. With the aid of the teachers, school science teaching and learning activities were built around the emergent interests of the learners. Findings pertaining to learner engagement included, "the greater the degree of connectedness with the learning material, the deeper the levels of engagement with each other and the teacher" (p. 116). In addition, "learner engagement was much higher during the activity phase of the lesson, irrespective of the content: learners like to interact with their peers and in doing so, construct meaning" (p. 116). Effective concept development, problem solving experience and immediately useful science knowledge are deemed advantages of localizing curriculum and contextualizing learning needs. However, concomitant to the positive findings, Stears et al. recognize the inherent difficulties of locally defining curriculum within the broader context of national curriculum and learning outcome expectations.

Standards

The scopic influence of national curriculum and learner outcome expectations is a contextual reality for the participants of the study. The literature reviewed herein is guided by a sociocultural paradigm that students learn science within multiple embedded contexts. Through a sociocultural paradigm, learners make sense of the world via social structures and cultural interactions facilitated by psychological tools such as language and technology (Kozulin, 1998; Kyle, 2004; Polman, 2004). The social structure of schooling for United States and South Africa learners emanates from standards-based accountability systems. However, many of the studies reviewed illustrate that meaningful and useful learning in science ought to be relevant and linked to the life-world experiences of learners. Learner success within the larger society in terms of advanced schooling and career opportunities rests on progression within the socials structure of formal schooling. Thus, if development of a scientifically literate citizenry and empowering students for practical action are goals of an education in science, learner success within their respective schooling systems must be avowed.

Learner participation in the STC program is suited to national science education standards of the United States and South Africa. The standards documents of both countries address the goal of learners understanding science is a human endeavor. “Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity” (National Research Council [NRC], 1996, p. 170). “Careful selection of scientific content, and use of a variety of ways of teaching and learning science, should promote understanding of science as a human activity” (South Africa Department of Education, 2002, p. 5). The South African National Curriculum Statement Grades 10-12 includes indigenous knowledge systems into the subject statements. The scope of the physical science curriculum for grades 10-12 states “that other systems of knowledge, such as indigenous knowledge systems, should also be considered” (South Africa Department of Education, 2003, p. 11). Considering indigenous knowledge systems in science education, as called for in the South African document, is comparable to nature and history of science strands of the United States science education standards. These strands include standards pertaining to the aspects of creativity, argumentation and debate as the hallmarks of the development of scientific knowledge and the historical practice of science by different people of different cultures.

STC participants shared an investigation adapted from the work of Keogh and Malcolm (2004) titled ‘Do You Think It Will Rain Today?’ pertaining to the water cycle. Learning objectives included understanding of the water cycle and its relationship to weather phenomena and plant and animal adaptation and survival. An additional objective for learners was determining relationships between cultural beliefs and scientific ideas about the topics of the investigation and sharing these understandings with their cross-cultural cohorts. These pedagogical activities matched national science standards expectations for the STC participants in the United States and South Africa. Science as a human endeavor, the nature and history of science and indigenous knowledge systems are each integral to the investigation. Content knowledge developed in the investigation is tied to grade appropriate national science standards for the STC participant middle school United States learners and grade 10 South African learners. Content standards addressed from the United States and South Africa science education documents, respectively, are:

Life Science – Regulation and Behavior

- Regulation of an organism’s internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.

- Behavior is one kind of response an organism can make to an internal or environmental stimulus.

- An organism's behavior evolves through adaptation to its environment. (NRC, 1996, p. 157)

Earth and Space Science – Structure of the Earth System

- Water, which covers the majority of the earth's surfaces, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle."

- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor.

- Clouds, formed by the condensation of water vapor, affect weather and climate.

- Global patterns of atmospheric movement influence local weather. (NRC, 1996, p. 160)

Agricultural Science – Agro-ecology

- Adaptations to ecosystems: adaptations of animals to specific regions, effect of weather phenomena (South Africa Department of Education, 2003, p. 26)

Life Sciences – Environment

- Biospheres, biomes and ecosystems

- Living and non-living resources, nutrient cycles and energy flow within an environment (South Africa Department of Education, 2003, p. 38)

- Adaptation and survival (South Africa Department of Education, 2003, p. 40)

Physical Sciences – Global Cycles

- The water cycle: Physical changes and energy transfers: The movement of water from the ocean and land surfaces controlled by energy in sunlight. Reservoirs for water on earth. Macroscopic properties of the three phases of water related to their microscopic structure. (South Africa Department of Education, 2003, p. 48)

Learning in a standards-based system is a commonality for the United States and South African students participating in the STC program. Multiple examples of content congruencies are evident upon examination of the national standards documents. Studying the nature of science and assessing knowledge claims are also stated goals for science education in both countries.

This research study will scrutinize the multiple epistemologies held by educator and learner participants of the Science, Technology and Culture: Empowering Learners project and the phenomena associated with the cross-cultural nexus of science, technology and culture.

Chapter Three

Research Methodology

Theoretical Frameworks

The theoretical framework underpinning the study consists of my view of the goals and purposes of an education in science using Habermas' (1972) critical theory of knowledge and human interests, as explicated in Chapter One. Habermas' three epistemological categories of empirical-analytical, hermeneutic and critical and corresponding technical, practical and emancipatory cognitive interests can be applied to the teaching and learning of science. Habermas' (1972) model can function as a cognitive schematic organizer for science educators who maintain the goal of the incorporation of each and all of the cognitive interests in science education. Habermas' technical cognitive interest is explored via the scientific method that attempts to be an objective, value-free search for knowledge. Scientists have discovered many causal relationships in the fields of physics, biology and chemistry. Educators who incorporate Habermas' practical cognitive interest acknowledge the humanity that ties the observer with the physical phenomena to be manipulated and observed. Scientific knowledge as a human creation is considered in the planning of teaching and learning activities. Habermas' emancipatory cognitive interest includes self-reflection on the parts of the teachers and the learners. Students learn to understand science as a fallible, human activity that is continually evolving. Scientific literacy becomes a goal so students and teachers may reflect upon, critique and engage in action-taking in the context of their lived experiences.

Science, Technology & Culture (STC): Empowering Learners is a unique program to broaden the understanding, appreciation and use of technology in high poverty communities, while offering youth a tremendous opportunity to enhance their scientific understandings and cultural awareness. The program focuses on the appreciation of technology and its application in scientific disciplines, as well as upon building cross-cultural relationships among people. The research study is an inquiry centered "on a phenomenon as it manifests within a specific context" (Piantanida & Garman, 1999, p. 133). Research questions emanate from the unique educational context and the function of the researcher as participant observer.

Taking the students' cultural surrounds into account eliminates a reductionist view of the student as an isolated agent. The research methodology is in concordance with my view of the embedded nature of learner understandings and the importance of the sociocultural context of schooling. Wertsch (1998) advocates examining mediated action as the unit of analysis for learning situations. A sociocultural paradigm incorporates "how mental functioning is related to cultural, institutional, and historical context" (p. 24). Technology serves as a cultural tool for learners and their families that mediates access to knowledge and thus participation in the generative nature of current knowledge and power structures. In his work in after school programs, Polman (2004) acknowledges the importance of temporal, social and cultural contexts for student meaning making. Students belong to many groups such as family, neighborhood, community, and school and "the cultural aspect consists of the ways in which language and tools such as computers are used and understood in the groups to which participants belong" (p. 4). Thus, an examination of the mediated action between STC learner participants across cultures is required in order to analyze communication.

Naturalistic inquiry is indicated as the most suitable framework for the study. Naturalistic inquiry is characterized by studying a phenomenon in a holistic fashion, acknowledging multiple realities of participants, including interaction between the researcher and participants, recognizing the complexity and nebulousness of the relationship between causes and effects in human interactions and acknowledging the value-laden nature of the inquiry (Lincoln & Guba, 1985). Thus, the researcher utilized various vantage points in order to gather and add dimension to data regarding the research question. Meaning from texts and artifacts was viewed not in a "single level of inscription" (Denzin & Lincoln, 2000), but as multi-layered and interwoven.

Research Questions

Learners participating in STC contemplate a myriad of cultural borders such as between and among everyday experiences, the canons of science, dominant and subordinate cultures and cultural/indigenous knowledge while engaging in discourse with a cross-continental cohort. The journey to scientific literacy addressed in United States and South African science education standards is bound up in the embedded understandings of learners. The researcher's role as a STC participant observer affords opportunities to study learner artifacts and to interact with learners and educators in order to gain knowledge about how learners form scientific understandings of the world, the relationship between cultural/indigenous knowledge, everyday science and content learning goals and the effect on cognition of discourse with a cross-continental cohort.

Given the unique embedded understandings of students participating in the STC program, and the technological facilitation of cross-cultural discourse, the primary research question guiding the study is:

> *What are the cultural/indigenous understandings of the STC participants during the technologically facilitated scientific and cultural learning experience?*

The pursuant secondary research questions were used to focus the investigation and target data that would illuminate the primary research question.

What are the perspectives and beliefs of the South African educators involved in the STC learning experience?

What various ways of knowing about scientific phenomena are expressed by participants?

What changes in thinking and ways of knowing occur over time as learners engage in cross-cultural scientific pedagogy and discourse?

Definition of Terms

Defining terms is necessary for guiding research design and conducting meaningful analysis of data. For the purpose of this study, terms will be defined as follows:

Learners – Youth, educators and community members involved in the STC program

Cultural Border Crossing – Crossing borders between and among everyday experiences, the canons of science, dominant and subordinate cultures, home, school, neighborhood and community surrounds

Cultural/Indigenous Knowledge – Distinctive ways of knowing about scientific phenomena and understanding the world resulting from assimilation into a culture; includes beliefs and assumptions

Scientific Discourse – Formal and informal ways of understanding and communicating about scientific phenomena and the nexus between science and culture

Scientific Literacy – Knowing and understanding scientific concepts and processes and possessing the ability to apply them in real world decision making

Mediated Action – A unit of analysis for the human sciences that distinguishes "the role played by "mediational means" or "cultural tools" … in human action" (Wertsch, 1998, p. 17)

Contextual Realities – Temporal, social and cultural contexts of human beings

Identity – Perception of self that is embedded in ethnic, gender, peer, family, school, community and societal contexts

Study Participants

In the fall of 2003, the STC program director that is a Professor at the University of Missouri – St. Louis, a Professor from the University of KwaZulu-Natal in Durban, South Africa and a graduate student at the University of KwaZulu-Natal identified 3 Township high schools with computer laboratories and Internet access. However, the Internet access was limited to the Principal's offices and using the Internet was not a regular component of the student computer laboratory activities. The STC representatives explained the program and elicited interest in participating in STC from administrators and teachers in the identified Township secondary schools. Rapport was established with individuals in the schools that laid a foundation for the researcher to visit the Township schools in June of 2004 to conduct professional development and instruct learners in order to continue the integration of the Township schools into the STC program.

Purposive phenomenological sampling was employed in the selection of study participants. The researcher's role in the Science, Technology & Culture: Empowering Learners program provided prolonged engagement with the program participants. The study participants were purposively chosen because of their ability to provide insight, information, perspectives and experiences related to the topic and setting under study (Gay & Airasian, 2000). United States youth partake in the STC program during the school year commencing in September and ending in May. The study was delimited to the period from fall 2003 through calendar year 2004 and included two sets of United States youth. The South African school year follows the calendar year. Thus, one set of African youth participated in the study. United States and African educators involved in facilitating the scientific and cultural educational program were included in the sample in order to add richness and triangulation to the pool of data. All study subjects gave informed consent and remain confidential (see Appendix B).

United States Participants.

The United States youth are middle school students and participate in STC as a free choice after-school activity or during the school day as part of a middle school science and technology curriculum. The African-American learners range in age from 10-15 years. The middle school learners participating during the school day reside in a poor, underserved ring area abutting the inner city limits of St. Louis, Missouri, USA. They attend a public middle school with an enrollment of 927 students. Eighty-three percent of the students in the middle school qualify for the federally subsidized free and reduced lunch program. The after-school STC participants live in a blighted area in the inner city of St. Louis, Missouri and attend a combination of the city public schools and private schools geared to poor populations. Their inner city environment contains a dearth of retail and service establishments and is riddled by burned out and demolished buildings. The STC program occurs as part of the after-school activities of two inner city community centers. Table 2 shows the STC enrollment numbers for United States youth learner participants of the study.

Table 2

United States Youth Learner Participants 2003-2004 and 2004-2005

2003-04 United States	**Learners**	**Girls**	**Boys**
Community Center 1 Advanced Class	7	4	3
Community Center 2 Beginner Class A	12	5	7
Community Center 2 Beginner Class B	8	5	3
Public Middle School Beginner Class A	13	6	7
Public Middle School Beginner Class B	13	8	5
TOTALS	53	28	25

2004-05 United States	**Learners**	**Girls**	**Boys**
Community Center 1 Beginner Class	18	8	10
Community Center 2 Advanced Class	13	6	7
Community Center 2 Beginner Class	19	7	12
TOTALS	50	21	29

South Africa Participants.

The South Africa youth are in grade ten in three secondary schools located in a Township outside of Durban in the KwaZulu-Natal province of South Africa. The black African learners of Zulu ancestry range in age from 15-17 years. One of the secondary schools has boarding facilities and one-half of the learners live most of the year at the school. The remainder of the learners resides in the poor Township where the schools are located. The secondary schools have a mean enrollment of 1,158 students. The STC program was conducted as part of the school day in computer technology classes.

During Apartheid, Black Africans, Indians and Coloureds were required to live in homogeneous groups in designated Townships of South Africa. The STC participants live in a Black Township located 45 kilometers outside of Durban. Despite over a decade since the end of Apartheid, the Township population of approximately 221,000 is 98% Black Africans (Census, 2001). Housing is a hodgepodge of freestanding simple homes and shanties put together with discarded wood, metal and auto parts. Shanty areas adjoin the schoolyards. The shanty areas are devoid of pipe born water and electricity. Roads are mostly unpaved, rough, rutted and not designated via street signs. The Township bustles with adults and children congregating on the streets and taking group transportation into the city for work. Poverty is the norm. Using informal methods, learner needs for food and clothing are addressed at the schools. The public school uniforms are saved and handed down. Educators and community members cook breakfasts and lunches at schools for learners in need. Schools open early to provide study times for learners who do not have sufficient accommodations at home. Table 3 shows the STC enrollment numbers for South Africa youth learner participants of the study.

Table 3

South Africa Youth Learner Participants 2004

2004 South Africa	**Learners**	**Girls**	**Boys**
Secondary School 1 Beginner Class	19	9	10
Secondary School 2 Beginner Class	18	8	10
Secondary School 3 Beginner Class	13	6	7
TOTALS	50	23	27

South African educators involved in the STC program were also included in the sample for data expansion and triangulation. The participant researcher from the United States recorded field notes in a journal and conducted interviews with three South African classroom teachers instructing the STC program, two South African principals of the schools and a South African university instructor serving as field coordinator between the United States and the Township sites.

Instruments and Procedures

Researcher as Instrument.

In the course of a two-year period, I had many roles in the STC program including instructing learners, evaluating the program, supervising instructors, writing curriculum and facilitating the introduction of South African schools to the program. STC contains a dual year curriculum of beginner and advanced classes. I instructed a beginner class in 2003-04 and an advanced class in 2004-05. The majority of the beginner class completed the advanced class with me. Thus, a closeness and familiarity naturally developed with that group of continuing learners. I maintained congenial rapport with all the learners and their families emanating from a sincere interest in and enjoyment of the youth. Evaluating the program and supervising instructors via surveys, focus groups and discussions and documenting the outcomes in reports and articles in development for publication provided an opportunity for reflection. This reflection spawned depth and richness to meanings that under girded program phenomena. The experience of developing a technologically-based environmental module for STC honed my skills for incorporating science content and process into the unique educational setting.

The month of June 2004 was spent in the South African Township schools facilitating their participation in the STC program. This time was invaluable for developing an understanding of the non-United States cultural context of STC. I was definitely an authentic outsider as a white Western woman in Black South African Township schools. A Black African woman instructor from the city university, who was also a township resident, accompanied me at all times. A friendship developed over the course of the weeks with this woman who helped ease my introduction to the people in the township schools and bolstered my personal safety. At no time in the entire month did I view a white person other than myself in the township. Children in the streets often pointed at us driving by and called "white woman" in the Zulu language. Despite my obviousness as an outsider, the educators and learners welcomed me with sincere openness. It was my pleasure to work with them and help the learners develop their first artifacts for the STC website at http://stc.umsl.edu. Working in the Township schools illuminated cultural similarities and differences and constraints on STC participation pertaining to lack of time and resources. This first hand experience and understanding contributed to my skill level for conducting the study and completing data generating and analysis procedures.

I am confident in my expertise as a mature educator with experience at kindergarten through higher educational levels and in urban, suburban and rural contexts. I am confident in my ability to conduct qualitative research because I have routinely done so as part of practice and as a dissertation rater. Thus, I have a foundation upon which to understand educational phenomena. However, it is incumbent upon me to reflect on possible biases and assumptions that may influence my performance as a research instrument. Venturing into the inner city of my midwestern metropolis and the confines of the South African township were fearful experiences at times. White, Black, Indian and Coloured South Africans who were colleagues, friends or strangers routinely warned me about my safety during my work in the province. As a white outsider moving about in poor, crime-ridden areas predominantly inhabited by black African-Americans in the United States and Black Africans in South Africa, I often carried a protective awareness with me. Did my lack of trust in my safety negatively affect my trust in the people I met? Was this potential bias stronger in the foreign context of South Africa? In addition, my Western ways of speaking quickly and anticipating speedy results had potential to harm my working relationship with the South African educators and learners. Did I interpret what I perceived to be slow progress as a lack of motivation or work ethic on the part of the South Africans? Also, I desired to guard against viewing black African-Americans or Black Africans solely from a group identity paradigm. Would I think black African-Americans act this way and Black Africans act that way? The rigidity of this view would prove constrictive to my understanding and data analysis. This research study is one lens into the educational phenomenon of interest. Although this single picture is validated by a thorough research design and data triangulation, the partiality and open incompleteness inherent in a participant researcher conducting naturalistic inquiry are acknowledged.

Researcher Journal.

The researcher recorded journal entries following each STC instructional session describing the session and corresponding perceptions. The work in South African schools was also documented in the journal. Although the journal reflected the researcher's authentic perceptions, this secondary data may have low fidelity to the research question due to the participant status of the author. The journal was low structure in order to free the researcher to document what was deemed personally important or memorable. Instances regarding the illumination of various ways of knowing, cultural understandings, cultural border crossings and student marginalization from dominant culture were documented. Reflection pertaining to cultural differences between the Caucasian instructor and African-American and Black African students was noted. Feelings, perceptions, emotional attachments, frustrations and concerns of the researcher were freely recorded in this format.

Electronic Communication Between and Among Cohort Learners.

Learners were given numerous opportunities to share ideas and information with cohorts within and across continents. STC curriculum facilitates the communication of cultural and scientific understandings such as family, school and community activities and science topics of common interest such as weather, animals, water and the environment. This primary data has high fidelity due to the authenticity of student ideas and low structure due to the open nature of student communication via e-mail and postal mail written by individuals. Communication was facilitated with researcher interest in the topics below:

How do cohort learners identify themselves within their respective cultures of school, family and community?

How do learners profess to form scientific understandings of the world?

How do everyday science understandings correspond to school science?

How do cohorts receive these ideas?

Do learners experience undertaking the perspective of others in this process?

What cultural/indigenous knowledge is expressed in communication?

Do changes in thinking and ways of knowing occur over time?

Do learners discuss avenues for action-taking in the context of cultural and scientific issues?

Routine pedagogy included the practice of learners receiving e-mail from the instructor enumerating the tasks and goals for the current STC class. The instructor e-mails often served as scaffolding tools used to encourage learner communication. For example, during a module about the water cycle the learners received e-mail guidelines for a letter to their cross-continental cohort (see Appendix C).

Artifacts Produced by Learners.

Students produced many technological artifacts within the context of STC including biographical WebPages, PowerPoints, photographs and digital videos. Artifacts were posted on the STC website at http://stc.umsl.edu for cross-continental cohorts to view (see Appendix D for web links to example learner artifacts). Objectives of the specific artifacts focused on sharing culture such as interesting places to visit and scientific understandings such as reasons, explanations and predictions for weather related phenomena. Student artifacts have high fidelity due to individually generated authentic student ideas and high structure due to curriculum rubrics and instructions for the digitized tasks (see Appendix E). Artifacts were developed to help illuminate the holistic picture of the research phenomenon in terms such as:

What does the artifact say about how the learner identifies him or her self?

What does the artifact note as important to the learner in terms of valuable scientific or cultural knowledge?

Does the knowledge of the shared nature of artifacts with cross-cultural cohorts affect the artifact production?

How are the artifacts received and understood by cohorts?

Is cultural/indigenous knowledge expressed in the artifacts?

Interviews with South African Educators.

The researcher conducted interviews with three South African classroom teachers instructing the STC program, two South African principals of the participating STC schools and a South African university instructor serving as field coordinator between the United States and Township sites. Although 3 Township secondary schools participated in the study, one of the initially identified schools did not join the program and an additional secondary school was added. Thus, only 2 principals were interviewed during my visit in June 2004. The formal, field based interviews were semi-structured and framed by a preset protocol (see Appendix F). The main goals of the interview were to learn demographic data about the Township schools, information about the learners, the educator's orientation and ideas about cultural/indigenous knowledge and its relationship to school learning and the major challenges faced by the educators and learners. The role of the interviewer was somewhat directive while simultaneously including a flexibility that allowed the pursuit of understanding "the complex behavior of members of society without imposing any a prior categorization that may limit the field of inquiry" (Denzin & Lincoln, 2000, p. 653). The interviews were manually transcribed during the interview in order to foster rapport with the interviewee in the context in a developing country.

The transcription gave high fidelity to the interview data in the context of semi-structured protocol.

Parent/ Family Member Survey.

The STC survey was directed to the population of parents or significant adults of United States community center participating learners in fall 2003. Each of the twenty-seven learners received a cover letter, survey and stamped return envelope (see Appendix G). However, the assumption of a marginal return rate was present. Although a self-addressed stamped envelope was included with the survey, a marginal return of 12 surveys or approximately one-fourth of the parents completed and returned the instrument. However, a majority of responses illustrated a high level of satisfaction with the program. The purposes of the survey were context specific to the STC program and participants. Since the common nickname for the STC project among participating families was the African Cultural Program, the survey used that nickname to refer to the program.

The five main goals of the survey reflect an informal method to gain knowledge about the learners regarding their cultural context. Survey items addressed:

Presence and use of technology in the home

Significant adults engaged with the learner in terms of helping with schoolwork and interfacing with the STC program

Family configuration

Significant adult's perception of the importance of technological access and skills to the learner's future

General program feedback and relative importance of reasons for participation

Obtaining perceptions and opinions of significant adults in the lives of STC learners is a latent variable. Perceptions are not easily observed and manifested and aspects of the latent variable are not constant. Individual survey items were not considered to be comparable indicators of the latent variable. Thus, the classical measurement model and associated path diagrams did not apply. Numerous technology and survey studies were reviewed in order to obtain a baseline item pool. Items were evaluated and adapted to suit the needs of the STC program and the goals of the survey. The research base guided the development of survey items.

After the survey was given to a pilot STC class, a focus group consisting of university doctoral students and a university professor fluent in research methodologies was employed. Feedback from the focus group included suggestions to alter some of the survey response choices. Survey Form B was developed as a result of those suggestions (see Appendix G). Each of the three classes was assigned different colors for the survey printing. Two weeks after dissemination of the survey, a family follow up letter was distributed. The follow up letter enumerated new STC program developments and encouraged families to continue to submit surveys (see Appendix G). The simplicity of the frequency distribution analysis was indicated due to the variable nature of the survey items and forms and the context-specific small sample of respondents (Woolfolk, 2001). Frequency distributions were conducted on survey results for the three STC classes.

Data Analysis Plan

The five data sources of researcher journal, electronic communication between and among cohort learners, artifacts produced by learners, interviews and parent surveys were transcribed when necessary. Each data source was organized and analyzed in a five-step process.

Step One – Data was read and examined for emergent themes. Emergent themes were color-coded and described.

Step Two – Data was read and examined the second time to confirm or falsify emergent themes and to identify sub-themes. Emergent themes and sub-themes were color-coded and described.

Step Three – Expert One was consulted as a second data analysis rater. If necessary, themes and sub-themes were revised.

Step Four – Data was read and examined the third time to confirm or falsify emergent themes and sub-themes and to establish triangulation of themes in data.

Step Five – Expert Two was consulted as a third data analysis rater. If necessary, themes, sub-themes and triangulation points were revised.

Possible Thematic Frameworks.

Data analysis was based upon, but not limited by, paradigms present in peer reviewed research literature. A sociocultural paradigm views the actions and thoughts of human beings as emanating to and from their cultural surrounds (Bruner, 1990; Wertsch, 1998). Technology was viewed as a cultural tool that gives individuals access to knowledge and the larger society (Kozulin, 1998; Kyle, 2004; Polman, 2004). Thus for the purpose of data analysis within the setting of the study, the computer was viewed as a cultural tool used by human beings within social, historical, institutional and cultural contexts.

Ogawa's (1995) and Ogunniyi's (1998) categorizations of Western science and indigenous science were used for the purpose of analyzing and understanding data. According to Ogawa, western science is understood as a production by a community of scientists. Indigenous science is held by a group and passed down from generation to generation via language and cultural events. Beliefs about weather are often used as an example for such differences. Ogunniyi further delineates the categories by describing Western science as Mechanistic and based solely on physico-chemical reactions of living and non-living entities, and the African worldview as Anthropomorphic and based on personal, rational and metaphysical logistics. Although Ogawa and Ogunniyi explain Western and African views, evidence of indigenous scientific beliefs of the United States and South African learners was sought during a thorough analysis of the data.

Regarding the cultural components of learning, the structure suggested by Jegede (1997) was considered for the process of data analysis. Jegede describes the five cultural components of Authoritarianism, Goal Structure, Traditional Worldview, Societal Expectations and Sacredness of Science. Descriptions of the components for the purpose of this research are below:

Authoritarianism – To what extent does the learner express belief in the power of the authority of elders in the community and teachers?

Goal Structure – How does the learner express goal structure in terms of individual, co-operative, and/or interdependent goals for learning and behavior?

Traditional Worldview – How strongly does the learner express beliefs and superstitions learned from indigenous knowledge systems? Are such beliefs separated or embedded in the STC learning experiences?

Societal Expectations – How does the learner define school achievement? Is it defined in terms of individual goals or is it linked to the learner's role in the community?

Sacredness of Science – How does the learner view the value, worth and practicality of school science versus indigenous science?

This cultural component learning framework was applied to United States and South African students during the process of data analysis.

Possible outcomes of the interaction between learner preliminary ideas and the science teaching and learning process have been examined by Jegede (1995) and Osborne and Freyberg (1985). Although the categorization of learning outcomes after the science teaching and learning process differs between authors, learning results are described as residing along a continuum. Jegede's collateral learning theory between Western and Indigenous thought contains parallel, simultaneous, dependent and secured learning outcomes. Osborne and Freyberg's learning outcomes include undisturbed thinking, two-perspective thinking, reinforced ideas, confused outcome and unified science outcome. Such learning outcome continuums include the possibility of the student maintaining preliminary ideas along with school science ideas in parallel fashion, the student becoming cognitively confused about the place of disparate ideas, and the student remodeling cognitive schema to unify scientifically acceptable views and useful preliminary knowledge. The data analysis process for the research study discerned for clear evidence of such categories for student learning outcomes. However, more importance during data analysis resided on evidence of useful knowledge between cultural groups as advocated by Kyle (1999), without the constriction of placing such knowledge into categories. Thus, student understandings and communications about pertinent scientific phenomena such as weather, animals, and ecology was analyzed for evidence of the development of useful knowledges for individuals and between cultural groups.

Delimitations, Limitations, Validity and Reliability

Purposive sampling in the selection of study participants was a delimiting factor. The study was delimited to the time period from fall 2003 through calendar year 2004. The participant researcher had greater prolonged engagement in the United States context than the South African context. Methodological tools utilized for data gathering served as lenses into the phenomenon and delimited the amount and type of data collected. Study limitations were attributable to the employment of the naturalistic inquiry method. The researcher studied the phenomenon in a holistic fashion, acknowledged the multiple realities of the participants and interacted extensively with the learners, educators and families. Limitations must include recognition of the complex and nebulous nature of human beings and the difficulty inherent in any attempt to establish a relationship between causes and effects in human interactions. The meanings individuals associate with their actions are often implicitly and intricately unique. The value-laden nature of the inquiry also functions as a limitation of the study. However, within the delimitations and limitations, meanings and understandings relating to the research questions were revealed.

Reliability for the research study was established by checking emergent themes with findings of other credible, current research literature and consulting experts during the data analysis process. Internal validity was established by prolonged engagement of the researcher with the phenomenon under study, participatory and persistent observation, and triangulation of multiple data points in an attempt to authenticate study findings. All study participants have parallel realities despite residing in different continents in terms of marginalization from the dominant society, thus founding external validity of study findings.

Since the research inquiry was an attempt to understand constructions of the world of participants in a holistic fashion, the research design was allowed to emerge and flow according to the iterative and recursive nature of grounded findings. The natural and unique setting of the study precluded predictions about the patterns of mutual shaping of cultural and scientific understandings that were to unfold (Lincoln & Guba, 1985). The goal of an analysis of study findings was to provide an inductive picture of the cultural/indigenous understandings of the cross-cultural study participants, the perspectives and beliefs of STC educators, the various ways of knowing about scientific phenomena and changes in thinking and ways of knowing that occurred during the technologically facilitated scientific and cultural learning experience.

Chapter Four

Results and Analysis of Data

The embedded scientific and cultural understandings of learners and educators participating in the Science, Technology & Culture: Empowering Learners program were examined using the following data sources: 1) interviews with South African educators, 2) researcher journal, 3) learner electronic communication, 4) learner artifacts and 5) family survey. The five data sources informing the study provide a scopious and deep picture of the experience and perspectives of the participants of the STC program. Data gathered within and among the five sources serves as the foundation for answering the main research question of the study:

What are the cultural/indigenous understandings of the STC participants during the technologically facilitated scientific and cultural learning experience?

The pursuant secondary research questions also were used to focus the investigation and target data that would illuminate the primary research question. Data pertaining to the following pursuant secondary research questions were analyzed and synthesized in relationship to the main research question.

What are the perspectives and beliefs of the South African educators involved in the STC learning experience?

What various ways of knowing about scientific phenomena are expressed by participants?

What changes in thinking and ways of knowing occur over time as learners engage in cross-cultural scientific pedagogy and discourse?

Pursuant/Sub Research Questions

Sub Research Question One: *What are the perspectives and beliefs of the South African educators involved in the STC learning experience?*

A 'do whatever it takes' attitude permeated interviews with South African educators. They hold an expansive vision of schooling and education that included using unofficial ways of nurturing learners so they could succeed in school. This view is compatible with Kyle's (1999) vision of social justice for all education. The educators provide learners with informal breakfast and lunch programs, outside of school hours supervised study halls and creative ways for payment of fees. The educators maintain the inclusion of morning assembly into the school daily schedule in order to impart moral direction, build Zulu pride and give learners a sense of the larger purpose of schooling.

South African educators value the African traditional worldview and see discordances between the indigenous knowledge and mandated curricular goals for schooling. In fact, during STC activities with her class conducted by the program director from the United States, Zandile professed belief in the power of Sangomas to direct lightning. The educators express their identification with African tradition and the Ubuntu philosophy of personhood through others and the worldview of a collective self. This worldview is apparent in the execution of an expanded vision for schooling. Although national standards advocate inclusion of indigenous knowledge systems, the educators see challenges with western science written from the white man's point of view and making science content relevant to learners. Ogawa's (1995) definition of western science as understood by a community of scientists can imply a community defined by the white man's point of view. Jegede's (1997) cultural component of learning called the sacredness of science was noted via the lack of educators obtaining science degrees and use of under qualified science teachers.

Discordances between the changing nature of South Africa and maintaining traditional culture and indigenous knowledge were noted. The educators are conflicted about the need and mandate for HIV/AIDS education in the context of African tradition that discourages sexual behavior in youth. Teachers perceive difficulty with learners' completing homework, the need for aggressive classroom management in light of the end of corporal punishment and robberies committed on travelers as signs of a loss of African cultural tradition and the Ubuntu philosophy.

The educators explain many instances of the marginalization of teachers and learners in their schools. The educators discuss the irony of the existence of game parks, rivers and reserves within reasonable driving distance of the township and the fact that most of their learners have never visited the sites. They describe learners having no background of experience outside of township life to bring to school and the learning process. The educators feel uninformed about the developments and possibilities in science and technology education and cite the acute need for professional development. Success for learners outside of the township in terms of earning scholarships and obtaining quality educational results that are competitive in the outside world is a concern. Lack of funds and resources for schools also limits and marginalizes the teaching and learning process.

South African educators are aware of the importance of language as a psychological and thinking tool. The educators acknowledge the importance of facility with English for learners to be able to function in the business world and higher education venues. English is a second language for the learners behind Zulu, their mother tongue. Educators find it difficult to deliver instruction solely in English, particularly about difficult material. Helping learners write in

English is also a struggle. Differences in Zulu and English as thinking tools that affect teaching and learning are reported. For example, African numbers are descriptive and not exclusively quantitative like numbers in English. The Zulu word for six, isiThupha, means 'the right thumb' as in using ten fingers as the base for counting. Some Zulu counting words change according to what is being counted, such as cattle (Presmeg, 1993). These epistemological differences described by language have implications for math and science education such as completing the process of gathering and analyzing data.

Educator interviews reveal an acknowledgment of and struggle with a changing Africa. Educators are trying to:

- break the poverty cycle without losing valuable components of traditional culture,
- maintain learner discipline and classroom management without the use of the strict authoritarianism and corporal punishment of traditional culture,
- reduce the use of Zulu language in schools without discarding necessary thinking tools,
- maintain the custom of school wide morning assemblies that are no longer required by the South Africa Department of Education guidelines.

Sub Research Question Two: *What various ways of knowing about scientific phenomena are expressed by participants?*

Educators interviewed asserted African learners brought much science-oriented cultural/indigenous knowledge to school. This knowledge is explained as stemming from cultural practices of the learners' forefathers. The use of medicinal plants and belief in the power of witchcraft to control weather are given as examples. United States learners revealed cultural/indigenous knowledge in electronic artifacts from stage one of Do You Think It Will Rain Today? (see Appendix I). They explained animal and plant behaviors and cultural/indigenous knowledge of people that are predictors for the natural phenomenon of rain. Examples are simple contextual observations and oral knowledge from adults, such as:

> A dog's hair stands on end with thunder and lightning.
> My Mom says the corns on her feet hurt when it is going to rain.

United States and African learners contemplated the different ways of knowing of their cross-cultural cohorts. Learners compared via in class discussion and exchanging cohort e-mails the traditional African belief in the power of Sangomas to direct weather and the Native American tradition of performing rain dances (see Appendix J). Discussion centered on critical debate about whether such cultural/indigenous practices and knowledge constituted science. Excerpts from the e-mails of United States learners are below.

> N [STC learner] says Native Americans practiced science because they watched things and recorded information so they know how to plant. They probably recorded how the plants grew.

> A says she [the Sangoma] studies the environment to decide if it will rain and that is science.

South African learners' ideas expressed in e-mail included:

> We use to go to the mountain and do some sacrifices including slaughter a cow and pray to ancestors for rain. So we can make it rain by communicating with ancestors.

> No we cannot make it rain. They go or talk to a Traditional Doctor 'sangoma' and he or she uses bones to see if it will rain.

In conjunction with a presentation by a youth who spent 2 weeks in a rural African village, United States learners illustrated an openness and comfort level with different ways of knowing about scientific phenomena inside and outside of school walls. They gave examples of rural ways of knowing about scientific phenomena such as growing food and caring for animals that may not be presented in school curriculums.

Cross continental cohorts shared ways of knowing school science in electronic communication. United States and South African learners communicated what they deemed interesting about school science via factual tidbits and accounts of hands-on experiences. Excerpts from United States learners' letters are below.

> The most interesting thing I learned in school is that when you sneeze your heart stops.
>
> The best thing I learned in science was the body parts of a frog.

South African learners shared:

> The most interesting science we have learned is biology mammalian tissues.
>
> My science experiment is conducting a circuit by nichrome wire, bulb, switch, ammeter, voltmeter and cell and they all form a circuit.

Learners considered the use of language as a way of knowing and understanding scientific phenomena. United States learners were given examples of Zulu words that indicated animal or plant characteristics. " For example, *ku-Kahlele uHlalwane ko-Ba yi Ndladla*. (The Isoglossa has flowered, so there will be a famine). Some plants that live in very dry places, such as the isoglossa, produce their flowers, and therefore seeds, as a response to the stress of dry conditions. This helps the species survive, because the seeds can stay dormant in the soil until the rains come again" (Keogh & Malcolm, 2004, p. 123). United States learners brainstormed English words that explained natural phenomena to share with cross-continental cohorts via e-mail (see Appendix J) such as:

> Photosynthesis is how a plant makes its own food using the energy from the sun. Photo means light and synthesis means to make.

United States and South African learners expressed belief in the workings of a higher power as a way to explain scientific phenomena. In addition, some South African learners also used precepts from African traditional culture and indigenous knowledge as explanatory epistemologies. South African educator interviewees indicated most learners in the participating schools were Christians and held Christian beliefs in addition to cultural/indigenous knowledge. However, for the majority of learners, belief in epistemologies such as a higher power and/or African traditional culture/indigenous knowledge did not preclude belief in scientifically acceptable explanations for natural events such as the water cycle to explain rain. Learner e-mails and artifacts displayed a comfort level with maintaining multiple epistemologies to use in understanding the world (see Appendices L and M). Excerpts from one United States learner's e-mail are below.

> Q. What does the water cycle have to do with the rain?
> A. The water cycle has alot to do with the rain. The first step is precipitation. The next step is condensation and the next step is evaporation.
> Q. What is my own, personal belief on how rain happens?
> A. My own opinion is that the only one who can make it rain is Jesus.

Excerpts from a South African learner's e-mail are below.

> Well here in South Africa we have isangoma's who are called (witch doctors) and they have spirits and beliefs on their ancestors (the late ones)….So here in South Africa it is possible to make rain. The water cycle is one of the best and easiest way to understand rain….Well I used to believe that rain was natural don't get me wrong it is but now I also believe in the water cycle.

Thus, United States and South African learners exhibited many ways of knowing about scientific phenomena and multiple epistemologies for understanding the world around them.

Sub Research Question Three: *What changes in thinking and ways of knowing occur over time as learners engage in cross-cultural scientific pedagogy and discourse?*

Researcher journaling chronicled pre-existing biases held by United States learners regarding Africa and African culture. United States learners were judgmental about what they discerned as dirty living conditions and perceived their African cohorts as very foreign.

Comments and questions revolved around the perception that African cohorts had no money and 'junky' computers. However, as instructor scaffolding unfolded that coaxed learners to examine their biases and as learners corresponded with cohorts in Africa, changes transpired. Electronic artifacts and e-mails produced by United States learners during the course of the STC program revealed a growing personalization of and identification with African cohorts. Excerpts from artifacts and e-mails are below.

> So I expect to learn more from you and more about you through this pin pal process. I know already that my background is from Africa.
>
> I can't believe you love computers. I do too! I even built my own computer!
>
> I hope that you enjoy my letters to you. I also hope that you enjoy teaching me some things that I already don't know. It will be pleasant hearing and receiving letters from you.
>
> So if you ever get a chance pleases write back and also I am a girl a female pleases don't call me pin pall my name is myesha just call me mesh or me me or my my.

A male United States learner adopted an African name and researched its origins and meaning. After several months in the STC program, United States learners exhibited strong identification as African Americans via e-mail. Several learners expressed concern about how their identity as an African American would be viewed by African cohorts citing that people in Africa may not view them as true Africans. Learners also communicated a desire to dispel stereotypes in the perceptions of their cohorts. An example from e-mail is below.

> My cohort should know that I don't act any different than they do and that I don't think I am better than them.

Thus, changes transpired in United States learners as they moved from somewhat superior, judgmental attitudes to a desire for connection and acceptance from their South African cohorts.

The journal also recorded rising levels of risk taking with technology among the learners. As the learners gained confidence in their ability to interface with the computer, they required less explicit instruction pertaining to the completion of technological tasks. Learners took risks and used strategies learned such as investigating drop-down menus in order to accomplish electronic tasks.

As learners completed the Do You Think It Will Rain Today? module (see Appendix H), content knowledge about the water cycle was clarified. Preliminary discussions and artifacts produced in stage one of the module did not include learner expressions of the understanding of the water cycle and its relationship to the scientific phenomenon of rain. However, after completion of the hands-on investigation and producing collated electronic documents during stage two, learners enunciated scientifically correct understandings. Two examples are excerpted below.

> Heat helps the water evaporate more quickly.
> When the water vapor gets colder or hits something cold, it turns back into liquid water.

Reflection required in stage three of the module and follow-up communication about multiple explanations for natural phenomena helped learners determine any multiple epistemologies they held and think about the utility of maintaining them (see Appendices L, M & N). The original writings of the learners displayed facility with moving between the different explanations and causes for natural phenomenon. Excerpts from learner artifacts are below.

> There is more than one way to explain the ways of nature.

> Rain, God and the Water Cycle do happen together because god created rain and the water cycle happens automatically.

Thus, learners illustrated changes in views of Africa and African cohorts, risk taking with technology, scientific conceptual knowledge and reflection about maintaining multiple epistemologies.

Emergent Themes

The main research question of the study, *What are the cultural/indigenous understandings of the STC participants during the technologically facilitated scientific and cultural learning experience?* is best addressed by an examination of emergent themes generated by the data. Explicating data sources and connecting findings to the pursuant secondary research questions assisted in the identification of emergent themes. As a result of data analysis, interpretation and synthesis, the following five emergent themes were identified that answer the main research question.

- Marginalization
- Multiple Cultural Identities
- Multiple Ways of Knowing Scientific Phenomena
- Maintaining Multiple Epistemologies
- Change

Theme One: Marginalization.

Poverty marginalizes learners and their families from the larger society. The United States and South African learners reside in high poverty areas within their respective societies and have been disenfranchised from dominant economic, educational, health, technological and political processes. Examples of the marginalization of my learners from the activities, opportunities and discourses of the more dominant groups of our area arose often in my journal.

Noting the lack of retail or service businesses in their inner city environs, I realized and reported ramifications such as:

> What do the kids do when they need markers or poster board for a school project? Mom and Dad can't run out in the evening and pick up goods easily.

I inquired about the park located across from the community center for conducting outdoor science activities and center employees advised:

> Don't go there, even in the daytime. It is frequented by gang members and drug dealers.

In October 2004, our city's baseball team played in the division play-offs and the whole city was abuzz.

> Or so I thought before I taught class today. Schools in my burbs are having kids wear red, etc. The first game was in process at home in our city when STC class began, but the game was almost over. I inquired with the kids, "Who won the game?" and they looked at me with blank faces. The boys and the girls… They were barely even aware the Cards were in the play-offs although the game was in process literally right down the street from the center where we have class. How ironic – the people and kids way out in the burbs are really into the fun and excitement and the inner city kids who live a stone's throw from the stadium are marginalized again. I'd like to know how many inner city residents even attended the game that day. Very few, I'm certain. Tickets were hard to get. So another identity, a 'sports city identity' does not fit these kids. A baseball fan must have money to buy tickets, etc., time off work to attend a day game or time even to watch it on TV. Anyway, just struck me as such a glaring instance of being left out, marginalized, not part of the mainstream. Bless their hearts, I really want to help these kids acquire skills, get an education and pursue goals.

These everyday examples of marginalization recorded in my journal showed me in a real, tangible way the effects of marginalization and insulation on these learners. The exclusionary effects of marginalization define and limit the identity of learners as described in the previous example regarding United States learners' lack of identification with the sports town moniker of their city.

Another significant realization recorded in my journal during work in South Africa involved the identification and designation of youth by others according to their residence in high poverty areas of the United States and South Africa. For example, in the U.S. I often call my STC learners, my 'city kids' since they live in the inner city and I live in the county. In South Africa, I often heard the learners referred to as 'Township kids'. In both countries, those geographical labels have negative connotations. I noted:

> And that geographical space description means so much more than the space. My 'city kids' are often assumed to be black, poor, disruptive, and perhaps not bright by some people. I think many South African people may have same ideas about township kids and schools. Rural and township schools have a bad rap about laziness among teachers and learners, but I have not found that the case in these schools.

The United States and South African learners reside in high poverty areas frequented by crime. This serves as an oppressive, marginalizing factor. My journal excerpts from South Africa also apply to the United States participants.

> One major impression is the oppressive way of life here (in South Africa). On the one hand there is the oppression of poverty for so many people and on the other hand it is also oppressive for the 'haves' of this society because crime is so rampant and personal safety is always a concern.

Lack of safety limits freedom of movement and activities for learners, thus limiting the formation of background of experience and associated cognitive schema necessary for successful learning. Participant learners and teachers expressed a lack of security about their personal safety during the discourses of the Science, Technology & Culture: Empowering Learners program. The South African Zandile, a teacher at Isikole secondary school, expressed her fear of manning after school detention due to the prevalence of crime perpetrated by youth. Excerpts from electronic artifacts and correspondence between cross-cultural cohorts reveal the lack of security about personal safety.

Excerpts from United States learners' emails:

> My favorite work is math and I cannot get enough of it. On my street is a lot of shooting and kill. I am in the 6^{th} grade.

> The places I live at not the best but like it quiet sometimes but they don't do all shooting.

> One thing about [St. Louis] is that downtown is beau, the city part is kind of bad and is a lot of fight and murders but out in St. C. and St. P. is nice people.

Excerpts from South African learners' e-mails:

> [South African Township] is a place that is full of crime and I boarding at [Zothani Secondary School] is very good for us.

> I am a dayscholar. We are not safe at the school because the fence is broken and it is not safe for the boarders too.

> I live in a very big township called [Township]. There are many nice things about the township but there is also crime and poverty. I still love the township and all the people that live there.

South African principals and teachers described the insulated, marginalized lives of their learners that precluded them from having knowledge outside of Township life. The majority of Township learners do not come to school with background knowledge of African animals and their natural habitats or other concepts related to ecology. It is common for learners to have never seen an elephant, giraffe, hippopotamus or rhinoceros in the wild. However Promise, a teacher at Zothani secondary school, explained the goal of making science content more relevant to learners' lives stated in the recent South African educational standards. She noted changes in teaching practice, such as using the night sky and excursions to places such as the weather station in Johannesburg in order to make science content more relevant to learners.

> Learners like science more now because they can see how it relates to the whole picture of their world. More kids are interested in science.

In addition to the effects of marginalization on the construction of learner background knowledge and cognitive schema, South African educators noted the marginalization between their learners and the study of traditional Western academic disciplines. The principals assessed several discordances between school science and the lives of their learners. Principal Siyabonga stated:

> Science is written from the white man's point of view. There was a conflict between how we were brought up. We had to adjust to school.

However, he endorsed the preservation of indigenous scientific knowledge and passing it on to the learners. Principal Khulani found most science concepts foreign to his learners and teachers not adept at using everyday examples in order to make school science relevant. He professed the need for teacher training and professional development. He observed that math and science in South Africa were taught by under-qualified teachers who made the subjects unrealistic, impractical and unrelated to the lives of the learners. Khulani noted his experience at the university level:

> We only had 3 science graduates. People were scared to go for science degrees. Left many out.

Although national standards advocate inclusion of indigenous knowledge systems, the educators see challenges with western science written from the white man's point of view and making science content relevant to learners. Ogawa's (1995) definition of western science as understood by a community of scientists can imply a community defined by the white man's point of view. Jegede's (1997) cultural component of learning called the sacredness of science was noted via the lack of educators obtaining science degrees and use of under-qualified science teachers.

South African learners are also marginalized from the social structure of schooling via language. Promise, a teacher at Zothani secondary school, stated the biggest challenge for her learners was the use of English as the official language of schooling, although it was a second language for most of the learners behind Zulu, their mother tongue. Writing in English was a particular struggle for her learners. But, she noted that success in the working world would require her learners to be facile in the English language. Lizwi, the university instructor helping facilitate the program, also saw the biggest challenge in educating Township learners as English as the second language. She explained that some teachers just teach in Zulu and others speak in Zulu and then transfer to English.

Data revealed marginalization of United States and South African youth from their heritage. South African principals Siyabonga and Khulani explained identification with African tradition and the Ubuntu philosophy of personhood through others and the worldview of a collective self. They expressed a desire to break the poverty cycle without divorcing Africans from the past. Siyabonga lamented his belief that Africans were losing valuable components of traditional culture:

> We are losing some of the key things. Ubuntu is more than being human; it's sympathy and empathy. It's sharing. We Africans are losing that Ubuntu.

He stated Africans were lucky to know their roots and black Americans did not know their roots. Khulani recounted the role of school-wide morning assemblies in preserving African tradition.

> Morning assemblies are for the pride in us – Zulu African pride.

I was honored to be invited to morning assembly at the schools and developed a positive view of the practice.

> Assembly is a wonderful tradition and way to bring school family together at start of day. Deputy Principal explained the SA government policy has made assembly optional, but the school chooses to keep it for family, communal reasons. Teacher leads and students sing songs, dance, present skits, motivates. Deputy Principal introduced my escort, Teacher 'Lizwi' and she introduced me. Students very well behaved and stand in large crowd around school courtyard. I spoke to whole school via microphone and said Sanibona and Ninjani. Kids laughed politely and I made fun of my own attempts to speak Zulu. Also told them a bit about the program and my desire for them to speak to me when they see me. Explained my English may be very fast and hard to understand, so please feel free to ask me to repeat. Told them they are experts in their Zulu language

> and traditions and I did not have that knowledge. Assembly is also a way to preserve Zulu tradition and has a Christian, prayerful context also

The principals were conflicted about the necessity of HIV/AIDS education and its inclusion in South Africa's national standards in the context of African tradition that discourages sexual behavior in youth and instructs girls not to mingle with boys. They viewed the reproductive life curriculum in conflict with African traditional beliefs. The principals explained the practice of teenage girls wearing very short or braided hair as a cultural tool to discourage boy-girl relationships. Regarding relating with learners, the principals explained in traditional African culture it is disrespectful for youth to make eye contact with adults.

African educators lament the loss of components of traditional culture due to a changing Africa. Thus, adults and youth are beginning to be marginalized from their cultural heritage and its associated indigenous knowledge. The black adults and youth of the United States participants are also marginalized from their heritage as a result of the slave trade from Africa to the United States. Parents of United States youth participants completing a STC survey unanimously rated learning about African culture and communicating with children in Africa as primary reasons for their child's participation in the program. The unique perspectives of some of the United States parent survey respondents who completed an open-ended program feedback item are illustrated as follows:

> The African Cultural Program has helped our child's self –esteem. He looks forward to attending your program and he hates to miss.
>
> From the report I'm given weekly from my son, the African Cultural Program is quite stimulating. Learning about our culture more in depth was the initial reason he and I decided that joining could possibly be a good idea. He had no idea he'd have so much fun.
>
> African consciousness is always important to Africans. They need to know that teaching about the culture of such a GREAT people did not stop when the people were stolen and

> sold as animals. Africans gave civilization art, music, sciences, God consciousness and many more for the world.
>
> Next best thing to study abroad. So far very good!

Lack of resources and financial support for schools marginalizes the study participants from effectively using technology and the corresponding access to knowledge that technology affords. United States parent survey respondents expressed the importance of the acquisition of computer skills for their child's future. One hundred percent of survey respondents deemed the acquisition of the computer skills of keyboarding, word processing and creating presentations as important or very important to their child's future. One hundred percent of survey respondents deemed the Internet activities of learning about current events, using e-mail, job hunting and getting general information as important or very important to their child's future. One of the main goals of the Science Technology & Culture: Empowering Learners program is to help bridge the digital divide for learners who do not receive experience with technology in schools due to a lack of resources.

One significant day teaching my STC learners in the United States showed me a tangible example of the marginalization of my learners due to under resourced schools. On that day, the learners brought shoeboxes to class dressed in doll clothes as babies. It is a common young teen family life assignment to care for a psuedo-baby for 24 hours in order to simulate the responsibility of parenthood. I noted the disparity between the shoebox babies of my learners and the expensive life-like baby dolls that really cried used in the schools located in high socio-economic areas that my own biological children attended. But, we still had a chance for some discussion about how it was going as the learners cared for their shoebox babies and the immense responsibilities of parenthood.

South African principals and teachers gave many examples of school practices that attempt to fill the physical and mental needs of their marginalized learners. Principals Siyabonga and Khulani are strong educational leaders of successful schools in the Township. The principals displayed a ‘do whatever it takes’ philosophy illustrated in different ways of care-taking learners in order to facilitate learning. Free public education is South African policy, but schools receive little government funding. Learners pay fees to attend public school and wear uniforms. In accordance with the surrounding populace, Township schools have low fees. However, many learners are still unable to remit the fees. The principals explained unofficial ways of nurturing learners so they could succeed in school. Uniforms are handed down to learners, informal breakfast and lunch programs provide meals for needy learners and study halls are held outside of school hours. Principal Khulani personally supervises a study hall from 6:30am to 8am daily for grade 12 learners. He explained the need to provide electricity, water and light to learners who are living in 4 room houses without such amenities, along with families or extended families of perhaps 8 or more. Such conditions render it difficult for learners to study at home. He noted the study hall time helps him create a bond with the learners. Principal Siyabonga described creative ways of keeping learners in school. If he is aware the whole family is not employed, the parent will sweep, clean, cook or work in other ways at the school. However he notes a tension in his efforts to afford employment opportunities:

To some, we are punishing people for being poor.

Principal Siyabonga also explained judgment calls he must make in situations where parents profess the inability to pay school fees despite having jobs paying satisfactory wages. Prohibiting a child from attending school for non-payment of fees only further contributes to maintaining the poverty cycle for that child. However, accepting non-payment of desperately needed school fees from parents capable of remittance sets a destructive precedent. Siyabonga attempts to find a way to keep youth in school. These school practices reflect the African tradition of Ubuntu philosophy of personhood through others and the worldview of a collective self.

South African teachers also identified with African tradition and the Ubuntu philosophy and expressed concern that Africans were being marginalized from their heritage. Promise noted her view that the point of a school-wide morning assembly was to motivate learners to have hope and work hard despite their difficult circumstances. She shared information about a boy at that morning's assembly who was very poor and had holes in his shoes. She explained the comprehensive role of the school in his life to be open Monday through Sunday so he can have a secure place to study and succeed. Promise shared the importance of morning assembly to make explicit the larger purpose of schooling to learners.

> You've gotta dream. You can make it. Learners need motivation and someone to keep them focused. This is not just a place to pass the day. Let them know why they're here. They're here to do something. Because they are kids, they need someone here to remind them. Even if you're poor, you can make it if you work hard.

Zandile shared her fear of crime perpetrated by youth. If after-school detention is initiated at her school, she does not feel safe being left behind after school for learner detention supervision. However, she held a communal view of the situation.

> These thieves are our children – the children of our brothers and sisters. They belong to us. No matter what, we live a communal life.

Teachers in the South African schools are marginalized from training and professional development regarding technology and its pedagogical usefulness. Due to this isolation, teachers are also marginalized from current, dominant discourses of their profession in all areas. Promise expressed a desire to be informed about what is happening in science and technology education and the need for teacher workshops. At the age of 27, she viewed traditional teaching using books, chalkboards and exams as boring. She felt it was the role of the youthful teachers to bring about change. Promise saw workshops and training for teachers as vital, but seldom accessible to teachers in the Township.

School leaders are marginalized from the larger society evidenced by principals' concerns about the quality of their grades relative to success in the dominant society. South African principals Siyabonga and Khulani expressed pride in their successful schools, but were concerned about their learners succeeding in the world outside of the Township and their schools. Khulani reported his greatest challenge as the quality of results achieved by his learners.

> The greatest challenge is quality of results. What does an A at my school mean in the context of the outside world? Does it have clout in the outside world?

The principals want their learners to have the ability to compete for college scholarships and pursue their talents in the world outside their immediate environment.

The marginalizing effects of poverty for the United States and South African study participants reach into multiple realities. Living in poverty is exclusionary and limiting to the establishment of individual identity. Others also identify individuals in a negative, generalized way according to their residence in certain geographical areas. Study participants do not participate in many activities and discourses of dominant groups of their respective societies. The lack of feeling personally safe in crime-ridden environs is oppressive and does not promote a feeling of personal security. Study participants are marginalized from their cultural heritages due to lack of control over their lives and ramifications of a changing world. Lack of movement and experience outside of the immediate context circumscribes the experiences of marginalized youth. Although marginalized youth come to school with a background of experiences and pre-existing cognitive schema, it is often not an enhancement to school learning expectations. The social structure of schooling marginalizes learners in terms of curriculum associated with Western academic disciplines, particularly science, that is often not made relevant to South African or United States learners and instruction for South African learners in a second language. Lack of resources and funds for schools confines access to technology and the corresponding access to information and knowledge that technology affords. Teachers do not have access to training, professional development and the modern discourses of their profession. Schools with lack of resources struggle to connect with the larger society in terms of quality of results. However, in the United States and South Africa, educators and community members nobly and ably attempt to fill in the gaps caused by marginalization for learners under the umbrella of an expansive vision of schooling.

Theme Two: Multiple Cultural Identities.

South African educators identify with African tradition, cultural/indigenous knowledge and the Ubuntu worldview of personhood through others and a collective self. However, they strive for teaching and learning in English so youth may succeed in the larger society. Science content is viewed as Western and educators struggle with ways to make it relevant to their learners. The inclusion of indigenous knowledge is advocated by national standards, but there are no curricular materials to assist in that integration. The interpretation is that African educators have one foot in the beauty and tradition of their tribal cultures and the other foot pressed toward future success for their learners in an increasingly Western world.

Educators also view their learners as more Westernized than they were in their youth. Lizwi, the university instructor, identified with her Zulu ancestry and tradition, but shared that as a child she did not appreciate her heritage and thought it was old-fashioned. The meaningful tribal identification did not develop until she was an adult. Lizwi assessed the learners in the Township as very westernized and she was not confident in their identification with Zulu tradition and heritage. However, Lizwi displayed a strong feeling about the universality of African Ubuntu tradition. She explained Ubuntu as an African concept present in every tribe and viewed it as simple basic human principles of humility and respect and love for others. She saw similarities between the basic underpinning principles of Ubuntu and beliefs of other religions and cultures such as Christian beliefs expressed in the Bible and traditional beliefs of native groups of South America. However, Lizwi also noted that Africa was changing and losing some of the Ubuntu principles. She provided an example of the Ubuntu tradition of a traveler being welcomed in any home along the way of the journey for rest and food. That tradition is being lost due to the current condition of travelers being victimized by robberies.

The South African learners exhibited identification with Western culture in addition to pride in their African heritage. During my work with the South African learners, they were very eager to correspond with United States cohorts, learn about life in the U.S. and share about themselves. The South African learners displayed knowledge of popular teenage Western music and some stood in rapper style poses for photos. However, I explained several times that the South African learners needed to explain their Zulu culture, such as traditional foods and activities, to their United States cohorts. The journal records:

> They (the South African learners) have no idea so much of their traditions and lives will be so foreign to my western students.

E-mail communication excerpts of South African learners illustrate the dual identities.

> I am a Zulu girl and we Zulus are very proud of our culture and traditions even though we now live a modern lifestyle.

> I respect my culture as a Zulu person.

> On certain days when there is a traditional celebration we wear beautiful traditional attire with colourful beads and we enjoy ourselves a lot.
>
> My best musicians are B2K, Faboulas, Beyonce and Sean Paul.
>
> My favorite actor is Nicholas Cage and my favorite musician is Nelly.
>
> We as a Zulu people we love our culture and our heroes like Shaka Zulu (Great Zulu king), Nelson Mandela, Desmond Tutu, Walter Sisulu and Thabo Mbeki, our president.

However, letters from South African learners also illustrated strong Zulu cultural identity and the cultural transmission structures in place for the purpose of preserving Zulu tradition. A course in the Zulu language is a required component of schooling. Excerpts from South African learners' e-mails expressing strong Zulu identity and their perceptions of the associated cultural transmission structures are below:

> Our culture mostly depends on our ancestors as the messengers of God and we also have different religion like Christianity, Hinduism, Muslim, etc. We celebrate our heritage day on the 24^{th} of September every year. We also celebrate the life of King Shaka, a great Zulu King who died many years ago. Many people like to go and see the grave at KwaDukuza in Stanger. Our traditional attire (clothing) as Zulus are made of animal skin, we have isidwaba (for married woman) imigexo, which are made of beads, isicholo (a woman's hat), etc. They are all handmade. During heritage day we eat different foods like samp (it's a mixture of mealies and beans) isigwamba (mealie meal and spinach) isigwaqane (mealie meal and beans) izinkobe (dried, then cooked maize) etc.
>
> My favorite subject is IsiZulu, which is my home language. We learn a lot about things that were happening before we were born. We learn about how words were created in isiZulu, for example isiZulu is a tone language.
>
> Zulu is my least favourite subject because when you fail it you fail the year even if you pass all your other subjects.

One of the first electronic artifacts produced by STC learners is a biographical web page that is posted on the project website. The individual biographical web pages provide insight into the ways learners identify themselves within their cultural contexts. Learners worked from a rubric for the task that included guidelines for design and content elements (see Appendix E). However, the learners were allowed to personalize their web pages and add any information they desired. South African learners displayed a depth of identity in their personal web pages. They often noted the meaning of given Zulu names, stated career goals and described strong familial bonds (see Appendix D for web link examples). The biographical web pages of many South African learners disclosed identification with Western culture and a desire to visit the United States in addition to pride in South African citizenry and identification as a Zulu (see Appendix D for web link examples).

In e-mail correspondence, South African learners also expounded on ways they experienced additional multiple cultural customs and epistemologies. The multiplicity stemmed from Zulu tradition, the traditions of White South Africans, different organized religions and modern versions of tribal customs. Excerpts are below.

> In Zulu traditions we have two wedding ceremonies where we have a Traditional Zulu wedding and a white (church) wedding.
>
> Our Culture as Black South African, we slaughter cows and goats when we have certain ceremonies. We also pay "lobola" which used to be 11 cows in the olden days, now it is money to the family of the girl you would like to marry.
>
> Here in South Africa we eat the usual food but we also have our own traditional food that we cook now and then, like Maize, sweet potatoes, beans and samp.

United States learners did not express strong pride in their American identity, but did voice a desire for connection with their African heritage and identified themselves as African Americans in electronic communication after participating in STC for several months. However, the United States learners share lack of knowledge and connection with their African heritage. E-mail excerpts include:

> My culture comes from Africa well my ancestor do anyway they were slaves to, my heritage is African American.
>
> Somethings I would like to learn about is Africa's history, and my penpal.
>
> My heritage is very scattered.

> I think that this program will help me experience a lot more than I know about Africa. I really don't know much about Africa nor their heritage nor their background nor their culture. So I expect to learn more from you and more about you through this pin pal process. I know already that my background is from Africa.
>
> You are so exciting because you are from a different place but you know were from the same roots even if were born from a different place.

United States learners shared their identities in e-mail correspondence and biographical web pages (see Appendix D). United States learners identified themselves through their tastes in clothing, music, entertainment, what they were good at, likes and dislikes and characteristics of their environment. Excerpts from United States learners' e-mails are below.

> Right now and this time a lot of people are losing their jobs, but a lot of rappers are coming to (my city) like Chingy, Nelly, Murphy Lee and J-kwon who is from (my area) and another thing that I like to rap.
>
> I want to be a basketball player and have a gym. The city is huge. We have lots of money to give you in the city and in the school.
>
> We have a mall that has rides and rock climbing and a movie theater, it is called the Mills Mall. It is so much fun.
>
> I love to shop at the Galleria because the rest of the malls don't have all the stores that I like.
>
> I'm also a girl and proud to be an African-American.
>
> My favorite hobbies are basketball and football. My favorite kind of food is fast food, like McDonald's or Burger King. I love looking at cartoons, too! My favorite cartoon stations are Cartoon Network, Nickelodeon, and Disney. The televisions shows are Powder Puff Girls, Proud Family, and SpongebobSquarePants.

The United States learners identified themselves as Westerners via expressions about the value of money in their lives. Learners asked many questions about their African cohorts relating to money. In an initial letter to his cohort, one United States boy generated clip art of money bills with no text and explained the money was to show his penpal what he was going to get when he got older. Our interchange and the recorded thoughts from my journal follow:

> I teased him and said, “Come on, you’re more interesting than that. What else can you tell him (cohort) about?” He said the money was to show his penpal what he was going to get when he got older. I said, “Why don’t you tell your penpal your plan for getting the money?” He replied something like, “I’ll be pimpin’ people (common slang, does not necessarily mean prostitution) and I will be a “F---“. I think he was naming a gang. I said, “Do you really think that’s going to get you there?” And he said, “No.” Money is very important and prized to these kids. They think it is their answer to life, but they don’t know how to get it. Hopefully, they will find people to help them get an education and see the value of education and work ethic for obtaining financial goals.

The United States and South African learners are poor within their respective societies. However, the United States learners’ e-mail correspondence also showed an appraisal of the importance on money and its value in their lives. This value was not illustrated or mentioned in the correspondence from South African learners to their United States cohorts with the exception of the below.

> Here I don’t buy expensive clothes as you do.

Conversely, correspondence from United States learners often referred to the importance of money and its value in their lives.

> I like cars, shoes, sport, games, and that money.

> I mostly like shopping and dressing a lot of my money gose toward cloths and shoes. I pay about $50 on a pair of jeans.

> Some of my favorite things to do in [U.S. city] is to shop. I love clothes and accessories and everything else.

> My favorite class in school is math they say I like math because I like money.

However, the data produced by United States and South African youth shows a strong common identity source. Family is an important source of identity for both groups of cross-continental cohorts. A South African learner biographical web page is excerpted below (see

Appendix D for web link), followed by an excerpt from the e-mail correspondence of a different South African learner.

> We are family of 8, there are: Grand mother, Mother, Aunt, 2 brothers, my sister and me.My mother is a teacher.My family is very important in my life, that why I love my family and there good take of me.

> At home we are a family, big family, Mom, Dad, me, my twin brothers and my oldest sister and her little baby who is now 2 years old. We love one another and respect each other and care a lot for each other.

United States learners' e-mail excerpts are below.

> I have alot of sisters 2-14.I live with my step dady Robin my mama Melanie my sister Jrodan.My real daddy live in the Bahamas…...My family is about to adopt a little girl named Angle. E-mail you later.

> I live in a very good family that loves each other a lot. My family is a Christian family, and love the Lord very much. I would describe my family as very out-going, happy, and caring.

> My family is not the best but yell sometimes at each other but we still love each other.

> My family is the best and I cannot get enough of them.

For the purpose of this study, identity is defined as the perception of self that is embedded in ethnic, gender, peer, family, school, community and societal contexts. The study participants display drawing upon these multiple contexts to form identity. Zulu ethnic identity and African American ethnic identity are revealed by South African and United States cohorts, respectively. Family identity is very important to both groups. Cultural norms are revealed in the United States learners' descriptions of identifying with western capitalistic values and pursuits. Zulu cultural transmission structures that are part of schooling are openly identified by South African youth. In addition, South African youth exhibited multiple cultural and societal influences on their identity, such as different organized religions, African traditional knowledge and values, and the practices of white African society. Thus, a theme emerges from the data of the multiple ways learners gain identity through Western and African cultures, structures and practices and family relationships.

Theme Three: Multiple Ways of Knowing Scientific Phenomena.

South African educators acknowledged their learners brought much science-oriented cultural/indigenous knowledge to school. Noting that much of this knowledge stems from the cultural practice of forefathers, Lizwi provided examples.

> Kids know you can use plants outside if you are sick. Like mothers crush plants to make a solution if babies are sick. Mothers use a syringe to draw in the solution and give it to babies for gas. Cultural beliefs about weather can relate to witchcraft. If the sun is up and then there are sudden clouds and a storm, people say that's how people practicing witchcraft test it. Our learners are younger; they may not believe it. But, they know about it.

The South African educators also pointed out possible implications on the teaching and learning process of the differences in using Zulu, the learners' mother tongue, or English, the language of school, as psychological tools. Lizwi provided the example of the cognitive process of counting.

> For example in Math, there are Zulu words for counting, but no one uses them. It takes longer to say words in Zulu, so everyone uses English. Like with counting, Zulu becomes cumbersome. African numbers are descriptive, not just quantity. The concept of counting numbers in the West is just 1,2, 3 and quantitative. African language is descriptive and kind of quantitative and qualitative. In the West, people count cattle to see if 1 head is lost. In Africa, I don't count my cattle. I just know them by name and color. For example, Africans don't count kids. We just know who is missing.

This sense of communal identity and 'just knowing who is missing' is consistent with the African Ubuntu philosophy of personhood through others and the worldview of a collective self. These differences in thinking can potentially affect process skills for science education such as observation and data collection. Jegede (1991) examined the science process skill of observation citing its central role in the scientific study of natural phenomena and found that students with a high level of belief in African traditional cosmology made significantly fewer correct scientific observations of biological structures and processes than students with a low level of belief in

African traditional cosmology. Although, Jegede's study was not about the use of the Zulu language as a psychological tool, African traditional cosmology is passed on primarily in oral form via the Zulu language.

South African educators shared tenets of African cultural/indigenous knowledge as one paradigm for explaining scientific phenomena. They also shared that learners may hold Christian and traditional epistemologies concurrently. The practice in the South African secondary schools of morning assembly routinely incorporated Zulu and Christian epistemologies. My journal and photographs during assembly recorded learners singing traditional Zulu songs and Christian hymns, performing skits about Zulu traditions and praying to a Christian God.

In February 2004, a white youth in the same age range as my learners shared with us his experiences on a trip to South Africa via a PowerPoint presentation. The speaker spent 2 weeks in a rural Zulu village in December 2003. Few white South Africans have ever spent extended time in rural Africa, much less a 10-year old white youth from the United States. We held a class discussion about preliminary ideas and ways of knowing before the presentation. My learners needed help with the distinction between rural and urban life in our area and application of the concepts to Africa. The learners illustrated an openness and comfort level with different ways of knowing as recorded in my journal:

> Asked about where we learn and ways of knowing. Kids were pretty open minded about learning outside of school building and ways of knowing. Kids acknowledged rural ways of knowing that may not be seen within school walls of things such as growing food, taking care of animals. KW said rural Africans might know about dirt. I probed why that would be important. Kids replied growing things. I had the misunderstanding kids would be judgmental about rural Africans' lack of school knowledge, but they did not seem to be.

Although the United States learners displayed a comfort level with thinking about different ways of knowing about scientific phenomena, when United States and South African learners were free to communicate electronically about any interesting scientific ideas, the correspondence centered on science as a subject in school. The learners understood the STC instructor generated conversation starter as somehow limited to a discussion of school science, although that restriction was not present. The learners were free to candidly profess a dislike for science or share something interesting without being required to provide factual or data driven support. United States learners often pointed to the idea of projects or making things in science class as interesting.

> In school I enjoy more than one subject. They are math, science, computer, and P.E. The reason I enjoy those four subjects more are because, you have to think, but when you think they make it fun.
>
> I like science because my classes have to make a submarine in science.
>
> My favorite subject is science the reason why I choose science because I like doing projects in science.
>
> Dissecting pigs
>
> The subject I hate is science though. I don't know why I just don't like it.
>
> My favorite subject is science because you get to project. My favorite science the body.
>
> I plan to learn about science and like it more.

South African learners expressed interesting school experiences in physical and biological sciences. Some learners saw a relationship between school science and future careers.

> My favourite subject is Biology as well as Physical Science. They are my favourite because I like to learn and I'm interested to know more about human being, animals, plants as well as other things that might help me in my career.
>
> The most interesting science I have learned is creating a circuit board that has a hooter and an alarm. It was very exciting.
>
> In science we learn about storms, acids, etc. and I enjoy it a lot.

> We have a Science Lab at my school and we sometimes do experiments. It can be very exciting.
>
> I also love biology because I learn about life and living things.
>
> Biology is my favourite subject because when I grow up I want to be a Dermatologist.
>
> My favourite subjects are Maths, Computer Studies and Biology because I understand them better than others.
>
> I don't like Biology because I am not good at drawing diagrams.

As described in Chapter Two, STC learners shared an investigation adapted from the work of Keogh and Malcolm (2004) titled 'Do You Think It Will Rain Today?' pertaining to the water cycle. Learning objectives included understanding of the water cycle and its relationship to weather phenomena and plant and animal adaptation and survival. An additional objective for learners was determining relationships between cultural beliefs and scientific ideas about the topics of the investigation and sharing these understandings with cross-continental cohorts. The learning objectives corresponded to grade appropriate national science standards for the United States and South African learners. The investigation was specifically chosen as a curricular intervention because it explicitly invites learners to reveal and examine cultural beliefs and their relationship to scientific knowledge. The enacted curriculum of the investigation was implemented in a three-stage plan with electronic artifacts resulting from the pedagogical activities of each stage (see Appendix H). The titles of the stages were:

1. Setting the Scene
2. Investigation
3. Can We Make it Rain?

The enacted curriculum also included instructor probing and scaffolding with specific questions designed to allow learners to grapple with the nature of science and examine multiple ways of explaining the world. Thus, the enacted curriculum was an authentic dynamic enterprise stemming from pedagogical experiences and cross-continental cohort communication.

The first-stage involved setting the scene for the investigation and determining learners' pre-existing knowledge regarding the water cycle. The United States STC classes engaged in whole group brainstorming and discussion sessions regarding clues that can be used to predict rain. The learners were encouraged to brainstorm clues from any epistemological source such as local, cultural and school science knowledge. The learners developed group electronic artifacts that grouped clues into categories and concluded with questions generated from the group discussion (see Appendix I). Excerpts from the artifacts reveal learner ideas about knowledge obtained from:

Social Media Structures

TV guide channel
Radio
Call the weather
Ask Jeeves
Look at the newspaper
The weather channel

Animal and Plant Adaptations and Behaviors

Dog's hair stands on end with thunder and lightning
Horses act scared – neigh and thrust backward
When the leaves on trees flip over, a swirling wind pushed the trees.
Geckos hide under leaf during thunderstorm
Birds act hyper.

Earth and Space Science Observations

Look for black rain clouds
Sounds – rumbling, thunder
Lightning
Air gets cold and windy
The air will get more humid.
The air will smell funny.

Indigenous Knowledge of People

> It gets hard to breathe because the air is thick.
> My mom says the corns on her feet hurt.
> Lick you finger and put it in the wind. Then if the wind blows one way, it will rain. If the wind blows another way, it will not rain.
> I get tired.
> My Grandmother's knee starts hurting.

South African learners had similar discussions with classroom teachers and the STC program director. Differences in weather patterns for the United States and South Africa were discussed in relationship to hemispheres, latitude and movement of fronts. The traditional African belief in the power of Sangomas to direct the weather was compared to the Native American tradition of performing rain dances. Nature of science and the idea that Sangomas and Native Americans may use observation and prediction as part of traditional rituals was considered. South African teacher Zandile actively participated in her group's discussion and "in fact asserted very firmly the notion that Sangomas have the ability to direct lightning wherever they wish" (W.C. Kyle, Jr., personal communication, October 14, 2004). The United States learners e-mailed the electronic artifacts enumerating their pre-existing ideas about the prediction of rain to South African cohort classes.

In addition, United States STC learners from the advanced and one beginner class sent a group letter to their cohort classes about some of South African learners' pre-existing ideas (see Appendix J). The group letters reflect active discussions during which the United States learners grappled with the nature and definition of science and knowledge and questioned their cohorts about African traditional knowledge. Ideas stemming from such debates are previously recorded under pursuant secondary research question 2 and additional data is expressed in the letters excerpted below.

> N says what the Sangomas do is science because science is observing and predicting what is going to happen and continuing to do the test until you get it right. If you don't get it right, you try again.
>
> B, B, B and C say the Sangoma will do a rain dance when it is dry and the crops need rain.
>
> N and A say the Sangoma will check to see if it looks like it's going to rain.
>
> Native Americans have rain dances also.
>
> T says watching nature and the environment was important to Native Americans so they could know when to plant their crops.
>
> J says if someone gets information and watches for information and says it is going to rain, they are not causing it to rain. But, they are predicting rain.

The advanced class discussion merged into the reasons animals change behavior before it rains. The learners cited the interaction between animals and their environment and developed a definition for adaptation shared in the cohort letter.

> B says the way animals are made and the way they act in response to the environment is called an adaptation.

Instructor scaffolding included examples of descriptive African words for animals and plants. The learners generated similar English words to share with their cohorts.

> Catfish are a fish that has whiskers like a cat.
> Sunflowers look like the sun and always turn toward the sun.

Stage Two of Do You Think It Will Rain Today? consisted of learners completing hands-on investigations about the water cycle and discussing the responses of animals and plants to changes in the environment (see Appendix H). The three United States STC classes worked in small groups on the hands-on investigation followed by whole group compilation of predictions and results. The class compilations were sent to South African cohort classes (see Appendix K). The whole group compilations of the hands-on investigation showed English words used to describe the scientific condition of hot air humidity levels that reflected the phenomenon. The language included words such as sweaty and musty and phrases such as, 'You can fry an egg on this sidewalk'. Learner predictions for the hands-on activity included naïve, but scientifically correct ideas such as, 'The hot water will make mist' along with scientifically incorrect ideas. However, upon completion of the hands-on investigation accompanied by discussion and debate about small group findings, the group-constructed artifacts illustrate scientifically acceptable explanations for the phenomenon excerpted below.

> Water has to go in the air for evaporation to happen.
> Water in the air has to come into contact with cold to condense into droplets.
> Hot water evaporates more quickly than cold water.

Thus, completing stages one and two of the Do You Think It Will Rain Today? module fostered an exchange and evaluation of ideas between and among cross-continental cohort groups that sparked creative and critical thinking about the validity and usefulness of different ways of knowing about scientific phenomena. The hands-on investigation of the water cycle was viewed successful in terms of clarifying some of the science concepts associated with the natural phenomenon.

Participating in the pedagogical activities of the Science, Technology & Culture: Empowering Learners program moved learners' multiple ways of learning from an implicit existence to an explicit plane. United States and South African learners revealed many ways of knowing as explanatory tools for natural phenomena with relative ease. Analysis, interpretation and synthesis of data disclosed the effects of language on ways of knowing and cultural/indigenous knowledge, traditional cultural beliefs, western religious beliefs, outside of school science experience, school-based science, observation and prediction, and hands-on investigations as ways of knowing about and explaining scientific phenomena.

Theme Four: Maintaining Multiple Epistemologies.

The purpose of stage three of Do You Think It Will Rain Today? was to allow learners to examine contradictions and similarities between different epistemologies after participating in the first two stages of the module and to express personal knowledge and beliefs to their cross-continental cohort. United States learners wrote to cohorts with guidelines contained in e-mail from the researcher (see Appendix C). South African learners replied to the same five items listed below.

1. Can we make it rain? If yes, how?
2. How do some people decide if it will rain?
3. What does the water cycle have to do with rain?
4. What is my own, personal belief about how rain happens?
5. Anything else you want to talk about or ask your cohort

The process of cloud seeding to encourage rain was discussed in the module along with the difficulty inherent in proving if human chemical intervention truly causes rain to fall from the treated cloud. However, the e-mails of the majority of United States learners reflect a belief that people cannot make it rain, but can only predict rain as evidenced by excerpts from e-mails below.

> No, we can not make it rain but we can predict if it will rain.

> I don’t (think we can make it rain). I truly think and believe that we can only predict because we don’t have the technology great enough yet. And the only people than can do most predictions are the meteorologists. That’s what I think.

United States learners explained various levels of understanding of the water cycle and its relationship to rain.

> What does the water cycle have to do with rain? I’m not sure about it. I think rain is caused by condensation and precipitation.

> Rain is water. As the cools, the water vapor (moisture) in the warm air condenses (turns) into water droplets. Droplets bump into each other growing bigger and heavier. When they become too heavy to float in the cloud, they fall to the ground as rain.

Many learner e-mails contained such explanations of the water cycle and rain while simultaneously expressing belief that God or a higher power was their personal belief for how rain happens. The original writings of the learners displayed facility with moving between the different explanations and causes for the natural phenomenon (see Appendix L). Excerpts from additional letters not included in Appendix L follow:

> The water cycle goes into the clouds. When the clouds are full, it rains. (What the water cycle has to do with rain) I think it rains because of God and science. (My own personal belief about how rain happens)
>
> Rain goes through a cycle before it actually starts raining. My personal belief is that God just makes it rain.
>
> The water cycle makes the seeds in the clouds turn into a gas and then into a liquid, I think that is how it works. My belief is that it rains when God makes it rain.

The letters from South African learners reflect multiple epistemological explanations for the natural phenomenon of rain (see Appendix M). The learners offer explanations from African traditional culture and indigenous knowledge, the water cycle and God. These multiple epistemologies often appeared within one letter from an individual learner. Excerpts from the writings of South African learners are below:

> When the dams, lakes, ocean, etc. are heated by the sunrays they'll form the water vapour (steam or gas), than the evaporation process takes place. A fact is that warm air rises and cold air sinks. In our culture we that if it is not raining for long period, we berg for the rain. We use to go to the mountain and do some sacrifices including slaughter a cow and pray to ancestors for a rain. So we can make it rain by communicating with ancestors. When this steam rich to the cold space or place it will become cold and form clouds they'll fuses and the condensation process takes place. Once the drops of water fused together they will become heavy the rain will be released. My belief is that in order to have rain there must be an enough evaporation occurring and lot of warm air to rise so that it will rich to the cold space and become cold and form a clouds and small drops of water than they will fuse together and form dark clouds and release the rain.
>
> I would like to tell you about patterns and signs of rain in our country I can say that we can make it rain. Well here in South Africa we have the so called isangoma's who are called (witch doctors) and they have spirits and beliefs on their ancestors (the late ones).

> And we all know that beliefs don't just come out from the blue there's a belief for a reason. For example if you people in America a certain race believes that if they have a rain dance in order for them to get the rain they need then definitely its going to rain. So here in South Africa it is possible to make rain. The water cycle is one of the best and easiest way to understand rain. Because it all starts in the evaporation process to condensation and precipitation. Well I used to believe that rain was natural don't get me wrong it is but now I also believe in the water cycle.
>
> Can we make it rain? If yes, how? No, because it is God that makes us rain it is not us that make it rain. Water cycle is the main source of the rain to rain because the water cycle is consist of many things like clouds, nature etc. My own personal belief that rain we cannot make it rain. Rain happens when God want it to rain it will happened in God's will not our will.
>
> No we cannot make it rain. They go or talk to a Traditional Doctor "sangoma" and he or she uses the bones to see if it will rain. When it is going to rain water changes into three phases from gas to water from water to ice from to rain. I don't have any beliefs on rain I think it just nature no one makes it rain.

Some South African learners communicated the sole explanation of the water cycle for the natural phenomenon of rain.

> The rain only falls when the water cycle had happened and I believe that rain falls by means of water cycle. My own personal belief in how rain happens, I believe that rain only happen because of the water cycle.

Thus, after participating in pedagogical experiences as part of the Do You Think It Will Rain Today? module, United States and South African learners expressed in electronic artifacts various levels of understanding of the water cycle and various epistemological reasons for the natural phenomenon.

After communicating with South African cohorts in conjunction with stage three of the Do You Think It Will Rain Today? module, the United States advanced STC class produced an additional electronic artifact guided e-mail from the researcher/instructor (see Appendix N for instructor e-mail and example learner artifact). The purposes of the guidelines were to gain additional information about how learners identified themselves, negotiated multiple epistemologies and changed ideas as a result of participation in the STC program. The seven guidelines designed to elicit learner reflection are listed below.

1. How would you describe yourself?
2. To what groups do you belong?
3. If you say rain comes from the water cycle and God, do you think they can both happen together?
4. Do you think there is one way to explain things in nature like rain or how the leaves on trees change color in the fall or do you think there is more than one way or more than one reason things in nature happen?
5. Why do you think we study science?
6. What do you think are the 2 most important things about you that your South African cohort should know that they may not know or may have the wrong idea about?
7. Have you learned anything about your cohort that you did not know before? Is there anything you have changed your mind about regarding the schools, learners or life in South Africa?

Pertaining to maintaining multiple epistemologies, a majority of United States learners held multiple epistemologies about God, the water cycle and the existence of different explanations for natural phenomena.

> I would say that the water cycle and god happen together but god does most of the work because he is what made it and he controls it and water cycle is just the title of his works.
>
> I think there is more than one way to explain mother nature.
>
> Through science they have more than one reason to things that happen in nature. I think we study science to learn and figure out new things.

However, one young lady described her struggle with her spiritual identity as a Muslim and the study of science.

> I believe that even though science is fun it's a way (to me) to prove God wrong. Can you be a scientist and believe in your religions teachings? I think the only way to explain it would be to read Gods word cause he has an explanation for everything. And he makes no mistakes. I think we study science so they can teach us some explanation for something they can't explain themselves.

Despite, or as a result of, engaging in teaching and learning experiences, United States and South African learners illustrated a comfort level with maintaining multiple epistemologies.

In my journal, I describe the practice of a school wide morning assembly in the South African schools as a way to preserve Zulu tradition embedded within a Christian, prayerful context. The South African learners begin each school day interacting with multiple epistemologies. Customs such as marriage are often celebrated with dual ceremonies by Black South Africans, one traditional and the other white or western. During the module, learners grappled with the nature and definition of science and knowledge in relationship to African and American cultural/indigenous knowledge. They examined the different epistemologies that emerged during participation in activation and hands-on activities of the module. South African learners were able to explain the phenomenon of rain through the lenses of multiple epistemologies.

United States learners partook in the same pedagogical activities, replied critically to traditional South African epistemology and reflected on the presence and usefulness of multiple epistemologies for explaining scientific phenomena. Many United States learners acknowledged the observation and prediction involved in the works of African Sangomas and/or Native Americans. They shared an expanded view of science that included such observations and predictions. However, the United States learners did not think it was possible for Sangomas or Native Americans to make or cause rain. Many United States learners spelled out correct aspects of the scientifically acceptable view of the water cycle while maintaining the understanding that a higher power also caused rain. United States learners responded to items designed to elicit reflection about multiple epistemologies and explanations for natural events. The original writings of the learners displayed facility with moving between the different explanations and causes for natural phenomena (see Appendix K). Thus, learners maintained multiple epistemologies as explanatory tools after engaging in scientific pedagogical activities. An important finding is that belief in multiple epistemologies did not preclude learner trust in scientifically acceptable explanations for natural events such as the water cycle to explain rain.

Theme Five: Change.

The emergent theme of change was derived from the data sources. African educators feared a loss of African tradition and cultural/indigenous knowledge as the nation continues to develop and frequently cited ‘a changing Africa’. Lizwi expressed the common view of the South African educators that Africa was changing and losing some of the Ubuntu principles. South African teachers fear a loss of classroom control due to changes in the acceptance of corporal punishment in schools. Promise at age 27 and the more mature Zandile noted that Africa is changing and questioned if Africans were losing their tradition in the process. The teachers noted the difficulty they had with learners’ completing homework as one signal of the loss of African tradition. Zandile disclosed her discomfort with the changes she saw in her school, Isikole secondary. She was concerned about the South Africa national shift to end corporal punishment in schools. Zandile stated her concern that learners would get out of hand as follows:

> We are meeting as a staff to discuss what measures we are going to take so it doesn’t get out of hand. What measures can we take for now? How to deal with learners in this new situation so they can learn and school can run successfully.

Zandile also expressed pride in the 100% matriculation rate at her school and the desire to maintain that success in the context of this change.

Lizwi viewed the reduction in the use of the Zulu language in schools and communication as another indicator of the change occurring in African culture. The use of the Zulu language is being drastically reduced in schools due to changes in teaching and learning expectations and learner outcomes. Loss of the indigenous language as a thinking tool is a concern. Change in the practice of school wide morning assembly required for learners brings concern over lack of school cohesiveness. Lizwi identified the change in African tradition of the new government policy that learners cannot be forced to attend morning school assemblies. She viewed the main purposes of the school-wide morning assemblies were to moralize learners and provide Christian guidance. Her experience was that learners and teachers come together as a school in the morning to pray and start the day. Black African schools also sing and celebrate during morning assembly. Lizwi had never attended an assembly at a white school, but did not believe white schools used assembly for religious or moral purposes and members of the school community did not express themselves via music and other art forms during assembly. Thus, as described in theme two, South African educators have one foot in the beauty and tradition of their tribal culture and the other foot pacing itself to keep up with a changing Africa.

Learners changed perceptions of cross-continental cohorts and moved toward personal relationships with each other. United States learners moved from pre-existing judgmental, superior attitudes about Africa and African culture to a personalization of and identification with their South African cohorts. United States learners produced PowerPoint presentations about places they would take their African cohort if he/she visited St. Louis and ended the presentations with comments like the following:

> I'd like to know about you. You should come with me. You will know more about me soon.

Learners accomplished adeptness with technology due to the technology skills targeted in the STC curriculum. My journal recorded rising levels of risk taking among the U.S. learners in the use of technology by applying problem solving tools such as drop-down menus to new and unfamiliar computer programs and tasks. Learners achieved clarity with scientific conceptual content and reflected about what constitutes science and different epistemologies during the Do You Think It Will Rain Today? module.

Learners consciously reflected upon the role of technology in their lives. The United States and South African learners realized their views regarding the importance of technology in their lives. In cohort electronic communication, technology was depicted explicitly as a vital tool for gaining information, a way to communicate with people and a vehicle for fun. United States learners' wrote:

> The most interesting science is the computer. I learned and received most of my information from school and home.
>
> I hope to learn a lot more about all the different things technology has to offer.

South African learners shared similar assessments:

> My favourite subject in school is Computer Studies because it makes me know many things and it teaches me that computer is a very important and useful tool and it plays an important role in our lives as people.
>
> Computer is my favourite subject, because it's got lots of interesting stuff and I love knowing new things and able to communicate with people on the internet like I will with my cohort and knowing how other people live, especially there in the U.S.

Learners changed perceptions about themselves as they learned about the lives of other marginalized youth of a different continent and a different culture. After interfacing with a white United States youth who spent 2 weeks in a rural African village and viewing his PowerPoint presentation, the United States learners expressed the realization that poverty in Africa is different than the poverty of their lives. Despite living in the poorest area of the city, most of the U. S. learners have electricity and an unlimited supply of running water. One of the learners remarked, "Gee I guess we don't have it that bad."

Learners moved toward a stronger identity with their cultural heritage. After completing several months in the STC program, United States learners responded electronically to the instructor e-mail questions below.

> How would you describe yourself?
> To what groups do you belong?
> What do you think are the 2 most important things about you that your South African cohort should know that they may not know or may have the wrong idea about?

Unlike their biographical web pages developed at the beginning of the STC program, all of the United States learners identified themselves as African American or black American. Additional group identities of the learners included peer distinctions such as popularity, sports teams and honor roll. Several learners explained their identity as African Americans and how native Africans may view it as evidenced below:

> I belong to Africa and nowhere else.

> I belong to Africa. People in Africa think that we are not African but if you are black you are African or African decent (descent).

The United States learners' responses to possible misconceptions about them held by South African cohorts unveiled a growing identification with their cohort, a strong identity as African American and concern about dispelling stereotypes.

> That I'm not rich, any kind of drug addict, and I have completely different views than President Bush.

> I am African American. Also I want her to know that I love rap especially Crime Mob.

> I think the 2 most important things that my South African cohort should know about me is that I am African American and that I am a straight A student.

> I really black and I really like rap music, very intelligent.

> I think that they should know that I am a boy and that I am black and not a crack head.

Thus, change was a constant in the experience of learners participating in the Science, Technology & Culture: Empowering Learners program. South African educators attempt to adapt to change in order to prepare their learners for the future, but are concerned about loosing their cultural beliefs and traditions. Learners changed their perceptions of others and learned to take on the perspective of others. Learners mastered technological skills. Learners experienced a stronger identification with their cultural heritages.

The contextual reality of the emergence of national standards in the United States and South Africa pertaining to what learners need to know and do in order to function in a global economy is guiding the process of schooling. Standards-based curriculums in schools influence the daily pursuit of knowledge for the study participants. Society expects educators to help all learners reach standardized educational goals. Marginalized learners who may be negotiating with multiple epistemologies arrive to classrooms directed by these expectations. Thus, changes in the larger context and in the expectations of society for the outcomes of schooling guide and guard learning. However, the marginalized schools in this study are underserved and under resourced as they attempt to keep pace with future opportunities and expectations for their learners that are continually changing.

The explication of the five themes that emerged from the data, Marginalization, Multiple Cultural Identities, Multiple Ways of Knowing Scientific Phenomena, Maintaining Multiple Epistemologies and Change, answers the main research question of the study.

What are the cultural/indigenous understandings of the STC participants during the technologically facilitated scientific and cultural learning experience?

The marginalizing effects of poverty for the United States and South African study participants are exemplified in multiple ways. The effects of their marginalization from their respective dominant societies encircle the cultural/indigenous understandings of the STC participants. Study participants do not participate in many activities and opportunities of dominant groups of their respective societies. However, study participants draw on multiple identity sources to form rich identities. Broad and narrow cultural norms, structures and practices and various forms of indigenous knowledge are identity sources for the study participants. Learners revealed multiple ways of knowing as explanatory tools for scientific phenomena with relative ease. Cultural/indigenous knowledge, language, cultural beliefs, religious beliefs and experience with the world inside and outside of school provided lenses for the study participants through which to understand scientific phenomena. United States and South African learners navigated between multiple epistemologies. Learners maintained multiple epistemologies as explanatory tools after engaging in scientific pedagogical activities. However, belief in multiple epistemologies did not preclude learner trust in and understanding of scientifically acceptable explanations for natural events such as the water cycle to explain rain. Change was a constant in the experience of study participants. Educators and learners negotiated their changing world through the lenses of their cultural/indigenous understandings.

Chapter Five

Discussion, Conclusions and Implications

Although the findings of the study support the paradigm of the social and political situatedness of the production of hegemonic and subordinate knowledge systems (Aikenhead, 1997; Barton & Osborne, 2001; Kyle, 2001; Leistyna & Sherblom, 1996), they do not support the premise that learners must sufficiently cross a cultural border in order to effectively learn science in school (Aikenhead, 1997; Ogawa, 1995; Snively & Corsiglia, 2001; Stanley & Brickhouse, 1994). Three main conclusions are determined from an analysis of the findings within the context of the literature and within the cultural ontology of the study participants. Implications for policy and practice are offered.

Discussion

Science education literature explicates the learner's process of navigating among the canons and concepts of science within a cultural context via the notion of cultural border crossing (Aikenhead, 1997; Jegede, 1997; Ogawa, 1995). Members of nondominant cultural groups attempting to learn school-based Western science may experience a complex process of connecting their worldview and ways of understanding scientific phenomena with the canons and understandings of Western science. The destruction of indigenous culture as an expense of assimilation into the canons of an academic discipline is not a desirable outcome (Aikenhead, 1997; Ogawa, 1995; Snively & Corsiglia, 2001; Stanley & Brickhouse, 1994). The participants of this study provided evidence of the view of school-based science as a different domain than their everyday worlds, but they did not illustrate border crossing into Western science that left other domains of knowledge behind.

South African educators acknowledged the utility of cultural/indigenous knowledge and discussed the adjustments learners must make to learn school-based science. The anthropomorphic, holistic nature of African cultural/indigenous knowledge (Jegede, 1997; Ogunniyi, 1988) was expressed by educators and learners. The educators pointed to the need to make school science more relevant to learners. The 'sacredness of science' aspect of the Socio-Cultural Environment Scale (Jegede & Okebukola, 1990) was manifested in the educators' accounts of lack of science education graduates and need for professional development for current teachers. South African educators shared their traditional worldviews in the context of teaching school-based academic disciplines as found by Ogunniyi, Jegede, Ogawa, Yandila and Oladele (1995) and Brand and Glasson (2004). When South African and United States cohort learners were led to initially discuss science, the majority of the discourse centered on factual tidbits learned during school-based science. Thus, a border between everyday science and school science existed.

However, the cultural/indigenous knowledge systems held by South African and United States participants were not the only frameworks they used to understand the world. The learners participated in cross-cultural scientific and technological activities that drew out multiple epistemologies and encouraged reflection about the utility of the different ways to understand natural phenomena. Learners predominantly expressed parallel collateral learning outcomes (Jegede, 1995) and two or multiple perspective learning outcomes (Gilbert, Osborne & Fensham, 1982). Some learners illustrated a level of dependent collateral learning (Jegede, 1995) by acknowledging multiple epistemologies, but determining a 'best way' to explain natural phenomena. The findings of this study illustrate learners' comfort level with maintaining multiple epistemologies as explanatory tools for natural phenomena. Thus, a continuum from preliminary knowledge to reconstructed scientifically acceptable knowledge evident in the models of Jegede (1995) and Gilbert, Osborne & Fensham (1982) was not displayed in the study findings.

Learners voiced multiple ways of knowing with relative ease and did not exhibit undue tension from cognitively grappling with multiple epistemologies. They were able to hold complementary and contradictory ideas simultaneously (C. Malcolm, personal communication, June 4, 2004) while gaining currently acceptable scientific knowledge about the water cycle. Thus, it was not necessary to assign status to different ways of knowing and learners were allowed to build useful knowledges (Kyle, 1999).

The value of language as a psychological and cultural tool was revealed as South African educators shared differences in mathematical thought systems demonstrated in Zulu and English words. Learners were introduced to the idea of language as a science thinking tool by searching for words that described natural phenomena in Zulu and English. Thus, making the role of language as a thinking tool explicit to teachers and learners is advised from the findings of the study in support of the work of Hodson (1993) and Lee, Fradd and Sutman (1995). Specific language use was not the focus of the study, but the role of language as the lifeblood of any culture must be taken into account in a sociocultural and mediated action (Wertsch, 1998) approach to schooling.

Conclusions

Purposive phenomenological sampling and prolonged engagement of the researcher with the study participants affords a synthesis of the findings in light of the literature and the ontology of the learners. The study supports three major conclusions.

Conclusion One: *Learners can successfully maintain multiple epistemologies as explanatory models to inform their identities and understand scientific phenomena.*

The South African educators identify with African tradition, cultural/indigenous knowledge and the Ubuntu worldview of personhood through others and a collective self. Concomitantly, the educators train learners in their non-native language in academic disciplines greatly influenced by the West. The educators facilitate learning within a standards-based system benchmarked by traditional written tests. School-wide morning assemblies are held to motivate learners, build school community, impart Christian values and share Zulu tradition. Thus, the South African educators live and work in multiple epistemologies.

Marginalization as a result of poverty bridled the identities of the United States and South African learners. Yet, United States and South African learners strongly identified themselves through their families. United States learners identified themselves through their Western cultural context explaining preferences and value in clothing and entertainment venues. After participating in the Science, Technology and Culture: Empowering Learners program, United States learners developed an additional sense of identity through their African heritage. In addition to strong family identification, South African learners identified themselves as Zulus and proud South Africans. South African learners also expressed identification with Western culture particularly in the areas of music, television and film. The learners drew upon multiple epistemologies to form and express their identities.

During the preliminary stage of a science investigation pertaining to the water cycle and its relationship to weather phenomena and plant and animal adaptation and survival, United States and South African learners identified and expressed multiple ways of knowing about scientific phenomena. Knowledge was activated and examined from cultural/indigenous knowledge systems, empirical observation, school-based science and social structures. During stage three of the module, learners reflected on the plausibility of multiple explanations for natural phenomena such as rain. Although learners offered explanations ranging from traditional practices, cultural/indigenous knowledge and religious beliefs, none of the ways of knowing precluded the learner from elucidating scientifically acceptable explanations such as the water cycle for rain. The learners' facility with multiple epistemologies potentially supports the work of Lemmer, Lemmer and Smit (2003) who suggest learners be introduced to the idea of paradigm shifts between organistic and mechanistic worldviews and multiple ways to understand the world in order to facilitate science instruction. Thus, contrary to the findings of Jegede and Aikenhead (1993), it is not necessary for science education to attempt to change learner ideas or fix learner misconceptions about natural phenomena. Science education has the potential to show learners different ways to look at and understand the world. Learners in the study illustrated the ability to navigate such different epistemologies successfully.

Conclusion Two: *Technology can give learners a voice and facilitate the development of global citizens.*

South African and United States learners discussed the importance of the role of technology in their lives freely and without instructor prompting evidenced in their electronic cross-cultural cohort communication. Although both cohorts groups are marginalized from the dominant discourses of their larger societies, the learners described the computer as a vital tool for gaining information. United States parent survey respondents expressed the importance of the acquisition of computer skills for their child's future. Obtaining access to technology and the corresponding access to knowledge that technology affords can help mitigate the effects of marginalization and disenfranchisement on disadvantaged youth.

Learners also expressed the value of technology for communicating with others and learning how other people live. The development of future global citizens will require the personification of cultural diversity curriculums. Study findings showed changes in United States youth away from biased ideas about South Africa and their cohorts. As United States learners corresponded with cohorts in Africa, they began to personalize their view of Africa and its people and take on the perspectives of others. Any global approach to problem solving will require communication and inter-cultural understanding. Youth learning, maturing and communicating with technology as a tool can help foster the development of global citizens.

Conclusion Three: *Learning science in a standards-based system needs to be relevant and contextualized for learners.*

Schooling in the United States and South Africa is guided and guarded by standards-based systems. South African teachers disclosed the lack of relevance of school science for their learners. Geographic and economic marginalization of the United States and South African learners limits the building of background knowledge to use as conceptual links for school science learning. Although standards-based contexts may narrowly define desired science content knowledge and learner outcomes, an expanded view of science education is required in order to promote meaningful learning.

Study findings during the Do You Think It Will Rain Today? module illustrate the utility of learners drawing upon and examining multiple ways of knowing as they learn science content and process. Relevant everyday examples and applications of science content knowledge naturally evolve with this pedagogical approach. Contextualizing learning can contribute to empowerment by putting “knowledge at the service of the people” (Kyle, 1999, p. 6). This points out the need for science educators, students, parents and community members to reflect about how science learning can be put to the service of the people.

Study findings exhibit the ease with which learners are able to examine, maintain and move between and among multiple epistemologies. Such reflection upon different knowledge systems can promote the application of knowledge in the lived experiences of learners. Thus, standards-based content need not be discriminatory to learners if educators create and use multiple pathways to the standards that build upon cultural/indigenous knowledge systems and cultural context.

Implications and Recommendations

The conclusions, implications and recommendations derived from the findings of the study are compatible with the theoretical foundation of the research by incorporating each of Habermas' (1972) three epistemological scientific categories and corresponding human cognitive interests. Science content knowledge dictated in a standards-based educational system is viewed as empirical analytic-science driven by a technical cognitive interest about how the world works. Educators may use flexible formative assessments and feedback from mandated tests to determine learner understanding of science content and process. However, instructional goals are based upon scientifically acceptable principles explicated in national standards. Incorporating cultural/indigenous knowledge and contextualizing pedagogy in the teaching and learning of science acknowledges scientific inquiry as a human activity in correspondence with Habermas' hermeneutic-interpretive science driven by a practical cognitive interest. Science principles may be derived from empirical-analytic methods, but understanding them is bound up with the interpretation of the learner. The importance of language as a cultural tool and the meanings learners bring to and from schooling fit the learner's mind to the world, rather than imprinting hegemonic knowledge systems onto the mind of the learner. Thirdly, Habermas' critical science involves learners engaging in critical reflection driven by an emancipatory cognitive interest. Study findings document learners engaging in critical reflection about multiple ways of knowing and understanding natural phenomena while engaging in scientific and technological activities commensurate with learning standards. Conducting the teaching and learning of science to include the emancipatory cognitive interest requires an expanded view of knowledge and consideration for the socially embedded process of knowledge formation.

Implication/Recommendation One: *Educational policy needs to include more than tacit reference to considering indigenous knowledge systems and study of the nature and history of science.*

Science standards documents of the United States and South Africa address the goal of learners understanding that science is a human endeavor. The South African National Curriculum Statement Grades 10-12 includes indigenous knowledge systems within the subject statements. Considering indigenous knowledge systems in science education as called for in the South African document is comparable to nature and history of science strands of the United States science education standards. However, the South African standards merely contain statements about indigenous knowledge and do not include content or systems for documenting and incorporating indigenous knowledge into science curriculums. Thus, the policies do not filter down to the practice of science education. An implication for national and school district policy is the active promotion of the development and use of units of instruction and teaching methods for dissemination to teachers that are context specific and incorporate indigenous knowledge. The designed and enacted curricular intervention of the 'Do You Think It Will Rain Today?' module (Keogh & Malcolm, 2004) is an example of one such unit of instruction.

Practicing science educators need to be involved in the development, dissemination and evaluation of such materials.

Spaces must be created within the educational system for documentation and critical inquiry into indigenous knowledge systems and study of the nature and history of science. Research and outreach of faculty and students of institutions of higher education in a transformative action research mode (Malcolm, Gopal, Keane and Kyle, in press) can create such spaces. Community generated ideas of what constitutes relevant science and the relationship between indigenous knowledge, school science and practical action can reveal the role of indigenous knowledge in relevant science learning. This would be a living example of science as a human endeavor.

Implication/Recommendation Two: *Intensive professional development is necessary in order to create multiple pathways to science learning standards.*

The teachers of the United States and South Africa must be actively involved in developing relevant, contextualized learning modules linked to science learning standards. Cultural/indigenous knowledge and the relevancy of science education are context specific. Teachers of a given area can come together to document cultural/indigenous knowledge of their learners, identify ways to make science content relevant to their learners, and develop pedagogical tools for field-testing. Pertaining to the documentation of African cultural/indigenous knowledge, Hountondji (2001) advises, “It is important to resist both romanticizing and rejecting traditional practices” (p.12). He points out that in the process of resisting hegemonic Western domination, Africans may not critically evaluate traditional culture and norms. Hountondji recommends Africans maintain their own internal cultural debate about indigenous knowledge and traditional practices; as cultures are dynamic, pluralistic and bound to change.

The development of relevant, contextualized learning modules requires teachers have mastery of science content knowledge and pedagogical knowledge. Field-testing would include the development of formative assessments and desired student artifacts that correspond to meaningful learning in a standards-based system. Continued tracking of learner performance on mandated tests and refining curricular tools make such professional development an iterative process.

I propose a model for professional development for teachers designed to create multiple pathways to science learning standards. The model is based on the conception of localized collaborative professional development and sustained formative and summative reflection and assessment of teaching and learning (Sparks and Hirsh, 2000). The components of the model follow:

- School district level educators and community members meet and identify what constitutes relevant science in their context.
- School district level educators, community members and available experts (e.g. from higher education, social institutions) document indigenous knowledge and cultural practices related to identified relevant science needs.
- School district level educators align relevant science needs and associated indigenous knowledge with science learning standards.
- School district level educators and available experts design relevant, contextualized learning modules linked to science learning standards.
- Teachers field-test modules and desired student artifacts.
- Teachers meet and share data from field tests and adjust modules.
- Formative module assessment continues on an ongoing basis until modules are ready for dissemination and videotapes of successful example lessons are developed.

- An iterative process continues with dissemination of modules, training for teachers and tracking of student achievement on standards-based assessments.
- Data is gathered in community regarding effectiveness of relevant science curriculum.
- Continued reflection and refinement of system.

This professional development model is described at the school district level and involves classroom teachers at all phases. In South Africa, the model can be applied at the Township level and expanded to inter-school district level or state levels in the United States.

Implication/Recommendation Three: *Solving global science and health issues will require the development of global citizens.*

Study findings promote meaningful learning for youth that includes examining multiple ways of knowing and making science relevant in context specific venues. Study participants also participated in cross-cultural discourse that promoted critical discussion about the nature of science, multiple epistemologies and taking on the perspectives of others. Science and health issues such as the AIDS pandemic, sustainable development and environmental preservation are global in nature. Thus, once meaningful contextualized learning in science is accomplished, it should be expanded upon by the application of scientific knowledge in other contexts for other people. Sharing knowledge of the disparities between the ‘haves’ and ‘have-nots’ on local, national and global levels and the effects of poverty on science and health issues is an important step in global problem solving.

Implication/Recommendation Four: *Technology is advocated as a tool to foster communication and inter-cultural understanding and contribute to empowerment for individuals in their cultural context and as global citizens.*

In the 21st century, technology is the most powerful tool for communicating and disseminating knowledge. Discourse between people via technology helps develop new knowledge and shared meanings. The social, political and economic systems are driven by technology. Access to technology and the corresponding access to information that technology affords can empower people to improve their lives and reach out to others. If the abilities to acquire new information and critically evaluate knowledge are paramount goals of educating youth, then technological access and literacy are vital. Developing youth into global citizens requires learning about the world outside of self and taking on the perspectives of others. Technology provides a vehicle for global discourse.

However, documentation in study data reveals that although several South African Township schools had computer laboratories, teachers lacked the training, support and professional development necessary to instruct learners in basic computer skills or incorporate technology into meaningful learning. Resources must be allocated to marginalized and disenfranchised schools in South Africa and the United States for technology hardware, teacher professional development and ongoing technical support. If resources are limited to obtaining technological hardware and software for disenfranchised schools, the realization of technology integration is unlikely to occur.

Further Study

South African educators appeared to have one foot in the beauty and tradition of their tribal culture and the other foot pacing itself to keep up with a changing Africa. If the concerns of the South African educators are realized and African tradition is being lost, documentation of cultural/indigenous knowledge needs to take place. Studies that record this knowledge that travels orally can help insure its preservation.

The role of indigenous languages as psychological and cultural tools employed for making sense of the world can be used in an interesting way for science learners. Studies that build upon the findings of this study and of Thomson (2003) pertaining to word and phrase usages that describe scientific phenomena can document indigenous knowledge and help learners use language more explicitly as a learning tool.

Teacher-leaders who develop multiple pathways to science education standards can conduct participatory, transformative, action research on their progress. Lesson analysis, the effectiveness of formative assessment, the explicit inclusion of cultural/indigenous knowledge and the relevancy of science concepts are all areas for study. Finding from these studies can inform the practice of science education regarding making learning in science meaningful, critical and relevant in a standards-based system.

Conclusion

This study focused on the nexus of science and culture in the lives of marginalized youth in the United States and South Africa. Finding a place within the current global educational context and conducting meaningful work requires individuals within the practice of science education to engage in critical reflection concerning the epistemology and ontology of science and the purpose of an education in science. The findings of this study reveal the multiple epistemologies and relevant ontology of marginalized learners. Success for learners within a globally radiating standards-based system for schooling requires them to provide evidence they have mastered identified conceptual content and process skills of science. The conclusions and recommendations of this study offer ways to make learning in science meaningful, critical and relevant in a standards-based system. Mastering science content and process along with relevant pedagogy and critical reflection fosters the development of learners who can become global citizens with the capability to adapt to change and become positive change agents in a metamorphic world.

"Imagination is more important than knowledge." Albert Einstein (1879 – 1955)

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Appendix A

Science, Technology & Culture: Empowering Learners Year One Curriculum

Weeks	Focus/Goals	Activity	Take Home Assignments
1	Introductions Microsoft Word	• Project/group/computer introductions • Project Application/Permission Forms • Project Pre-Survey *Activity: Design your own project folder cover using Microsoft Word* *Technology competencies:* operations, word processing	Get the project application and permission forms signed my parents or legal guardians
2	Microsoft Word	• Distribution of Project Folders (include a disk, pen, and introductory packet) *Activity 1:* Finish folder covers *Activity 2*: Tell me about Africa, Kenya, Nairobi short essays • Introduction to Africa (Kenya & Nairobi) • Word of the day 'Jambo' = Hello • Brief introduction to biographies *Technology competencies:* peripherals, operations, word processing	Bring Pictures (yourself, pets, etc.)
3	Digital Cameras Microsoft Word	• Graphics and pictures: using digital cameras and scanners *Activity 1:* Jambo Bwana Activity and Song *Activity 2: Biographies with pictures & graphics in Microsoft Word* • Introduction of digital cameras (pictures for the biographies) *Technology competencies:* peripherals, operations, word processing, multimedia	Design your own web page on one sheet of paper using your biography
4	Web Page Design Microsoft Word Clip Art	• Kiswahili words review *Activity 1:* Science discrepant event *Activity 2:Web Page Design Introduction using Microsoft Word Biographies - (background colors, text, clipart, text boxes, and saving to a disk)* *Technology competencies:* operations, peripherals, word processing, multimedia, web authoring	
5	Cultural	• Kiswahili words review	

Cultural Experience Microsoft Word Internet	• Kiswahili words review • Introduction to the Internet *Activity 1:* Website: http://pbskids.org/africa/ *Activity 2:* Work on bios/web page *Technology competencies:* operations, peripherals, word processing, multimedia, web authoring, technology/society	
Internet Microsoft Word Desktop Folders	• Kiswahili words *Activity 1:* Science discrepant event *Activity 2:* Creating folders on the desktop the desktop to store information (large files-bios w/ graphics) *Activity 3:* Web pages *Technology competencies:* operations, peripherals, word processing, multimedia, web authoring, technology/society	
Microsoft Word Digital cameras Internet	• Kiswahili words *Activity 1:* Science discrepant event *Activity 2:*Countries in Africa Word Search http://www.allstarpuzles.com/wordsearch/00034.html *Activity 3:* Web pages/ digital camera photos *Technology competencies:* operations, peripherals, word processing, multimedia, web authoring, technology/society	
Microsoft Word	• Web page checklist *Activity 1:* Finish Web pages, Web page presentations • Sign a holiday card for the kids in Kenya *Technology competencies:* operations, peripherals, word processing, multimedia, web authoring, technology/society	
Microsoft PowerPoint	• Introduction to PowerPoint *Activity 1:* PowerPoint group projects 'If your Kenyan pen pal came to visit St. Louis, where would you take them and why? *Technology competencies:* operations, peripherals, word processing, multimedia, electronic research, technology/society	
Microsoft PowerPoint	*Activity 1:* Finish PowerPoint Projects • Discuss Upcoming Projects *Technology competencies:* operations, peripherals, word processing, multimedia, electronic research, technology/society	

10	Microsoft	*Activity 1:* Finish PowerPoint Projects	

	PowerPoint	• Discuss Upcoming Projects *Technology competencies:* operations, peripherals, word processing, multimedia, electronic research, technology/society	
11	Microsoft Power Point Pen Pal Letters	*Activity 1:* Finish PowerPoint Projects *Activity 2:* Read and distribute pen pal letters from Kenya *Technology competencies:* operations, peripherals, word processing, multimedia, electronic research, technology/society	
12	Pen Pal Letters Microsoft Power Point Microsoft Word	• Pen pal letters, Power Point projects, science evaluation *Activity 1:* Finish pen pal letters *Activity 2:* Present Power Point projects *Activity 3:* Science Evaluation *Technology competencies:* operations, peripherals, word processing, multimedia, technology/society	
13	Science Evaluations	*Activity:* Finish science evaluations	
		SCIENCE COMPONENT	
14	Creating Maps Topography Internet Research Poster Presentations	*Geography*	Akura
		Weather & Climate	Jose
		Fauna	
		Vegetation	Monya
		Nutrition/Health	Akura
			Jose
		People & Culture	
		Urban Life/ City Life Presentation Preparations	Monya
		Final Presentations	

Earth Science and Geography:

	Description	Document by Week	Supplemental Materials
Week 1	Locating The Rift Valley, The Andes & Great Plains		Activity 1 Activity 2
Week 2	Locating Maasai Mara, Machu Picchu & Cahokia Mounds		Activity 3
Week 3	Putting together a poster board presentation		Poster Board
Resources	Internet/ Web Resrc Background Information Pictures & maps		Powerpoint Presentation

Weather and Climate

	Basic Activity	Document & Supplements	Docs
Week 1			
	Reporting the morning News ! Inspiration Brainstorming Instrument Activity	Video Forecast Short (S/T) Video Forecast Long (S/T)	
		Act1C-Instruments (S)	
		Web resources (NSCEP)	
		Weather Glossary (URL)	URL
Week 2			
	Jeopardy	Act2-2(A-C): St. Louis (S)	

		Act2-3: Website City Data	URL
Week 3	Advance skills with excel Starting Video Activity	Student Guideline 3.1 (S)	
		Group info. sheet 3.0 (S)	
		Storyboard blank 3.2 (S)	
		Web Resources	
Week 4	Video Project	Working Hard	
Week 5	Video Project	Videotaping your Weather forecasting.	

Explorations in Ecology © Copyright, Monya A. Ruffin, PhD			
	Basic Activity	**Document & Supplements**	**Docs**
Week 1			
	ENVIROQUEST CONSERVATION MATTERS	Explorations in Ecology Overview (T/S)	
		Weekone Activity (S)	
		Enviro Quest Crossword Puzzle (S)	
		Enviro Word List	
		Explorations in Ecology Packet (S)	
Week 2			
	PLANT MASTERS	Explorations in Ecology Packet- II(T)	
		Plant Masters	

Week 3			
	NEWSLETTER		
Resources	Envelopes		

Science, Technology & Culture: Empowering Learners Technology Competencies

Technology Competencies
Computer Operations
Use appropriate terminology (RAM, programming, modem, download)
Utilize desktop menu(finder/find, save, name, etc)
Differentiate use of mouse buttons for appropriate platform
Create Directories/Folders and subdirectories on local hard drive
Learn how to recognize file size
Navigate hard drive directories/folders, disk directories/folders
Save a file from a folder on to different drives
Open a file from a folder on to different drives
Use the COPY command to back up and share files/folders
Log onto a network using a personal password
Understand the user name, password and domain field of a logon box
Peripherals
Operate a Scanner
Utilize a digital camera
Recognize external computer peripherals (printer, zip drives)
Select a printer and print with appropriate page setup and orientation
Word Processing
Develop keyboarding efficiency
Format text with respect to size, spacing, style, justification and font
Save documents
Integrate spreadsheet and/or database files into a word processing document
Apply advanced word processing features such as columns, tables, and frames
Work simultaneously between multiple documents on the desktop
Utilize headers and footers where appropriate
Identify key commands (shortcuts)

Use print preview and page setup
Add and resize a graphic to word processing file
Transfer word processing skills to publishing flyers, brochures
Drawing and Painting
Adjust computer graphics using scale, size and shape
Spreadsheet
Understand the concept of a spreadsheet
Understand speadsheet terminology(paste function)
Collect and organize data using spreadsheet software
Increase width of a column/row
Enter advanced formulas and functions (average)
Utilize sorting and filtering features
Utilize multiple sheets within a workbook
Use spreadsheet to organize and calculate data
Produce a completed spreadsheet accompanied by a chart or graph
Electronic Research/Email
Organize bookmarks into folders for further reference
Retrieve information on a subject area topic via the Internet
Understand the function of a Search Engine
Navigate(WWW/Internet) using grade appropriate search engine(AltaVista, Lycos)
Utilize serach strategies to locate and retrieve electronic information
Communicate electronically via email(Pen Pal Projects, Letter Writing)
Utilize internal email tools; spell check, font, size, priority, preferencs
Learn to share text, grahics and sound files as attachments via e-mail systems
Mutimedia
Identify the components of a multimedia presentation
(text, graphic, sound video, and animation)
Develop an organizational plan and produce a slide show presentation
Import graphics/files into a presentation
Organize and rearrange slides
Use text transition and enhancement effects
Effectively time presentation
Web Authoring
Create a personal web page (in microsoft word)
Edit an existing web page
Create and apply links to and from other pages
Add text to a web page
Add graphics, clip art to a web page

Add a picture in JPEG format to a web page
Technology and Society
Work collaboratively at a computer with another student
Develop an awareness of acceptable use
Identifies the potential as well as the drawbacks of technology and its impact
on education, home, and the work environment
Source: the above competencies were adopted from Boston Public Schools
http://oit.boston.k12.ma.us/competencies.htm

Appendix B

Informed Consent Form

College of Education

8001 Natural Bridge Road
St. Louis, Missouri 63121-4499
Telephone: 314-516-6268
Fax: 314-516-7245
E-mail: kurzk@umsl.edu

Informed Consent for Participation in Research Activities

Using Science and Technology to Build Useful Cross-Cultural Knowledge

Participant ____ HSC Approval Number 040217K

Principal Investigator _Kathleen T. Kurz PI's Phone Number 314-516-6268

Why am I being asked to participate?

You are invited to participate in a research study about science, technology and culture conducted by Kathleen T. Kurz at the University of Missouri-St. Louis. You have been asked to participate in the research because you are a leader of a school participating in the STC program and may be eligible to participate. We ask that you read this form and ask any questions you may have before agreeing to be in the research. Your participation in this research is voluntary. Your decision whether to participate will not affect your current or future relations with the University. If you decide to participate, you are free to withdraw at any time without affecting that relationship.

What is the purpose of this research?

The research is studying the process of building cross-cultural useful knowledge between students in South Africa and the United States.

What procedures are involved?

If you agree to participate in this research, you can expect:

The study will involve groups of marginalized learners in the United States and the continent of Africa communicating electronically about scientific and cultural ideas. Data collection will commence in September 2003 and continue until on or before June 2005. Your input into the data collection process will include oral and written interviews and communication about the progress of the STC project in your school. Approximately 150 participants may be involved in this research at the University of Missouri-St. Louis, in St. Louis schools and community centers, schools in Kenya and schools in South Africa.

Risks and benefits of taking part in the research

The risks are minimal. Benefits include fostering the development of global citizens in learners and facilitation of technology support and instruction in your school.

Will I be told about new information that may affect my decision to participate?

During the course of the study, you will be informed of any significant new findings (either good or bad), such as changes in the risks or benefits resulting from participation in the research, or new alternatives to participation, that might cause you to change your mind about continuing in the study. If new information is provided to you, your consent to continue to participate in this study will be re-obtained.

What about privacy and confidentiality?
When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. If photographs, videos or audiotape recordings of you will be used for educational purposes, your identity will be protected or disguised. Any information that is obtained in connection with this study, and that can be identified with you, will remain confidential and will be disclosed only with your permission or as required by law.

What are the costs for participating in this research?
There are no costs to participation in this research.
Will I be paid for my participation in this research?
There is no payment for participation.

Can I withdraw or be removed from the study?
You can choose whether to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You also may refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so. If you decide to end your participation in the study, please complete the withdrawal letter found at http://www.umsl.edu/services/ora/IRB.html, or you may request that the Investigator send you a copy of the letter.
Who should I contact if I have questions?
The researcher conducting this study is Kathleen T. Kurz. You may ask any questions you have now. If you have questions later, you may contact the researcher at 314-516-6268.
What are my rights as a research subject?
If you have any questions about your rights as a research subject, you may call the Chairperson of the Institutional Review Board at (314) 516-589

I have read the above statement and have been able to express my concerns, to which the investigator has responded satisfactorily. I believe I understand the purpose of the study, as well as the potential benefits and risks that are involved. I give my permission to participate in the research described above.

All signature dates must match.

____ ____

Participant's Signature Date Participant's Printed Name

____ ____

Parent or Guardian's Signature Date Parent or Guardian's Printed Name

____ ____

Witness' Signature Date Witness' Printed Name

____

Researcher's Signature Date
(See guidelines on Who May Obtain Consent)

The Notice of Privacy Practices (a separate document) describes the procedures used by UM-SL to protect your information. If you have not already received the Notice of Privacy Practices, the research team will make one available to you.

_________ I have been offered a copy of the UM-SL Notice of Privacy Practices.

Initial

Community Center Registration and Permission Form

The African Cultural & Educational Exchange Program
Registration & Permission Form

Name: ________________________________ **Date of Birth**:________________________________

Address (with zip code): ____

Sex: _________ **Telephone**:________________ **School & Grade**:_____________________________

Name of Parent or Guardian: ____

Number of people in household: ___________ **Emergency contact number**:____________________

Participant (student) Signature: ____

Staff Signature: ____

Parent Permission & Support: My signature below indicates that I am aware my child, as listed on this registration form, is participating in the free after-school program called the African Cultural & Educational Exchange Program *(Sponsored by The Youth and Family Center and Herbert Hoover Boys & Girls Club)*. First year students will attend classes at the YFC and second year students will attend classes at HHBGC. Classes run for two hours per week between October 2003 and May 2004. The second year class at HHBGC will run from 4:30-6:30 on Tuesdays and the two first year classes at YFC will run on Tuesdays and Thursdays from 2:30 to 5:00.

I am also aware that my child will receive a free refurbished home computer and one year of free dial-up access to the Internet, **if** he/she participates fully in the program. The computers will be distributed at the graduation ceremony in May of 2004.

By signing this form:

A) I am agreeing to support my child's interest in this program, and agreeing to encourage their use of the home computer to further their skills and complete program activities.
B) I am accepting the responsibility for picking my child up after class, either from the HHBGC or the YFC.
C) I am approving the use of my child's photograph for reports, newsletters, or other sources such as the program website to promote or report outcomes of the program.
D) I am approving the use of any pre-tests or post-tests delivered by the instructors and/or projects produced by my student as a normal part of the curriculum to determine skills and complete reports. I am aware that the program curriculum and student projects are posted on the program website. Results will be used for project outcome reports to funding sources and to summarize the program outcomes in any educational journal or related scientific or professional publication. I am aware that my child's last name will not be released to any source.
E) I agree to complete program surveys as requested by the instructors in order to provide feedback. Results will be used for project outcome reports to funding sources and to summarize the program outcomes in any educational journal or related scientific or professional publication. I am aware the my name will not be released to any source.

F) I have been able to ask any questions regarding the program and they have been answered satisfactorily.

Please review the attached flyer for more information about the program!
Your child/children will have a great time and learn valuable skills.

Parent's or Guardian's Signature: ______________________________________
Date_______________________

Appendix C

E-mail Guidelines for Water Cycle Cohort Letter

Reply Reply to all Forward Help

From: UMSL, nascep_3 Sent: Tue 11/2/2004 1:30 PM
To: MY LEARNERS
Cc:

Subject: Week 7
Attachments:

View As Web Page

WHAT'S UP TODAY?

Hi everyone,

I missed you last week!
Attendance
You ought to be in pictures! See me.
Write to your cohort and we will insert your photo. (Practice their name :-)
Include:
1. Can we make it rain? If yes, how?
2. How do some people decide if it will rain?
3. What does the water cycle have to do with rain?
4. What is my own, personal belief in how rain happens?
5. Anything else you want to talk about or ask your cohort.

Try Shaq and Tara Lipinski's website game at http://www.staysafeonline.com

R-E-S-P-E-C-T It means all the world to me!

Always go well,
Ms. Kathleen

Appendix D

Web Links to Learner Artifacts

Kiswahili Dictionary:

http://stc.umsl.edu/participants/us-tyfc/class0304-K/files/word/Adiyah_Dict..doc

Weather Video – Select Jenay and Davion:

http://stc.umsl.edu/participants/us-tyfc/class0304-K/projects.htm

Public Broadcast System African for Kids Lesson Plans – Select Week 5:

http://stlouis.missouri.org/nascep/Missouri/Resources/teacher/lessonplans.htm

United States Learner Biographical Web Page with African American Designation:

http://stc.umsl.edu/participants/us-tyfc/class0304-K/files/BIOS/Kiasia_webpage.doc

Examples of United States Learner Biographical Web Pages:

http://stc.umsl.edu/participants/us-tyfc/class0304-K/files/BIOS/Adiyah_webpage.doc

http://stc.umsl.edu/participants/us-tyfc/class0304-K/files/BIOS/Ryan_webpage.doc

http://stc.umsl.edu/participants/us-tyfc/class0304-A/files/bios/TYFC2_Steven_Bio.doc

Examples of South African Learner Biographical Web Pages:

http://stc.umsl.edu/participants/saf-vukuzakhe/class0405/files/word/ALICE%20V%20WEBPAGE.doc

http://stc.umsl.edu/participants/saf-vukuzakhe/class0405/files/word/THOBISILE%20V%20WEBPAGE.doc

http://stc.umsl.edu/participants/saf-kwamgaga/class0405/files/word/Siyabonga.doc

http://stc.umsl.edu/participants/saf-kwamgaga/class0405/files/word/Duduzile.doc

Web Links to Learner Artifacts

Examples of South African Learner Biographical Web Pages with Western Influence:

http://stc.umsl.edu/participants/saf-vukuzakhe/class0405/files/word/Nkululeko.doc

http://stc.umsl.edu/participants/saf-kwamgaga/class0405/files/word/SANDILE.doc

http://stc.umsl.edu/participants/saf-kwamgaga/class0405/files/word/Ntombezinhle.doc

Appendix E

Rubric for Learner Biographical Web Page

NAME_____________________________DATE_____________

Your web page must contain the following main elements. Put a check mark in the box when you have included the item on your web page. Write your initials at the bottom when you are done and raise your hand to have your instructor sign off on your web page.

WEB PAGE DESIGN

- ❑ Background color
- ❑ Text
- ❑ Changed text alignment, font, and/or size
- ❑ Picture of yourself
- ❑ Picture of your choice

BIOGRAPHY

- ❑ Your name
- ❑ Your birthday
- ❑ Your age
- ❑ Live in St. Louis, MO, United States
- ❑ Middle school or High school
- ❑ Three things you like to do (Hobbies)
- ❑ Favorite music and food
- ❑ Family and/or pets
- ❑ Other:______________________

SAVE TO YOUR FOLDER

Your Initials________ Instructor's Initials ________

Appendix F

Interview Protocol South African Educators

Date and Time

School Official Name

Educator Name

School Address

School Phone Number

School Fax Number

School E-mail

School Website

Number of Learners Enrolled

Number per Grade Enrolled

Number of Educators

Where do learners live?

Can you describe your typical learner?

I am studying the cultural/indigenous knowledge similarities and differences between your poor, marginalized learners and the poor, marginalized learners they will communicate with in St. Louis, MO USA. But, I'm mainly interested in the useful knowledge they can build together as a result of getting to know one another and discussing scientific and natural phenomena. What kind of cultural/indigenous knowledge do your learners bring to the classroom?

Regarding science concepts such as the water cycle, weather, plants and animals, what kind of cultural/indigenous knowledge do your learners bring to the classroom? For example, my learners in the U.S. live in a concrete community of sorts and may be out of touch with natural phenomena such as the above. Their understandings about animals may come from one visit to the zoo.

What is the biggest challenge you face in educating your learners?

What is the second biggest challenge?

Anything else you would like to add?

Appendix G

Parent/Family Survey Cover Letter

November 13, 2003

Family Members of African Cultural Program Student
St. Louis, MO

Dear Family of African Cultural Program Student,

We've completed our first few weeks of the 2003-04 African Cultural Program. Thank you very much for sharing your children with us! We ask that an adult family member complete the enclosed survey about computer use and the African Cultural Program. **It is not necessary for you to provide your name. Your responses will be anonymous.** The information will help us plan and improve the program. **Please return the survey in the enclosed postage-paid envelope by December 1, 2003.**

Thanks again for allowing us to play a small part in the lives of your children.

Sincerely,

Kathleen T. Kurz
African Cultural Program Instructor
University of Missouri – St. Louis
Institute for Mathematics & Science Education & Learning Technologies
8001 Natural Bridge Road
St. Louis, MO 63121-4499
USA
Internet: kurzk@umsl.edu
Telephone: 314-516-4541
Facsimile: 314-516-7025

Parent/Family Survey Follow-up Letter

December 1, 2003

Family Members of African Cultural Program Student
St. Louis, MO

Dear Family of African Cultural Program Student,

We trust you had a nice Thanksgiving and we look forward to working with your children this week. Many families have returned the African Cultural Program Survey. Thank you for your feedback. The majority of families shared the importance of computer skills for their child's future. Most respondents listed learning about African culture, communicating with children in Africa and learning computer skills as the most important reasons for participation in the African Cultural Program.

We have some exciting news! Dr. Bill Kyle of the University of Missouri – St. Louis visited South Africa recently and organized three new schools for our program! The schools are located near Durban, South Africa and are equipped with computer labs.

If you have been unable to send in the survey, we encourage you to share your feedback with us. Obtaining feedback from everyone will help us continue to improve the African Cultural Program. If you have not done so, please return the survey at your earliest convenience.

Thank you for allowing us to play a small part in the lives of your children.

Sincerely,

Jose Pareja, Okongo Akura and Kathleen Kurz
African Cultural Program Instructors
University of Missouri – St. Louis
Institute for Mathematics & Science Education & Learning Technologies
8001 Natural Bridge Road
St. Louis, MO 63121-4499
USA
Telephone: 314-516-4541
Facsimile: 314-516-7025

Parent/Family Survey

AFRICAN CULTURAL PROGRAM SURVEY – B

Please check the blank.

1. How many working computers are in your home?

_____ None _____ One _____ More than one

2. Please identify the person completing this survey.

_____ Father _____ Mother _____ Grandparent _____Uncle _____ Aunt

_____ Stepfather _____ Stepmother _____ Other

3. Does your child use a computer at school?

_____ Yes _____ No _____ Don't know

4. Do you use a computer at work?

_____ Yes _____ No

5. **Please check the blank** that describes the importance of each of the following computer skills to your child's future.

A. Keyboarding / typing

_____ Very important _____ Important _____ Not important _____ Don't know

B. Organizing files (similar to organizing files in a file cabinet)

_____ Very important _____ Important _____ Not important _____ Don't know

C. Word processing (creating written documents such as letters)

_____ Very important _____ Important _____ Not important _____ Don't know

D. Creating presentations

_____ Very important _____ Important _____ Not important _____ Don't know

E. Solving math questions (creating data worksheets, spreadsheets, calculating)

_____ Very important _____ Important _____ Not important _____ Don't know

6. **Please check the blank** that describes the importance of each of the following Internet activities to your child's future.

A. Using online banking and investing

_____ Very important _____ Important _____ Not important _____ Don't know

B. Learning about current events in the news

_____ Very important _____ Important _____ Not important _____ Don't know

C. Using e-mail to communicate with others

_____ Very important _____ Important _____ Not important _____ Don't know

D. Job hunting

_____ Very important _____ Important _____ Not important _____ Don't know

E. Comparing and buying goods and services

_____ Very important _____ Important _____ Not important _____ Don't know

F. Getting medical information

_____ Very important _____ Important _____ Not important _____ Don't know

G. Getting general information

_____ Very important _____ Important _____ Not important _____ Don't know

7. How many adults live in your home? ________________

How many children live in your home? ______________

8. Who helps your child with homework? **Please check all that apply.**

_____ Father _____ Mother _____ Stepfather _____ Stepmother _____ Brother

_____ Sister _____ Grandparent _____ Uncle _____ Aunt _____ Cousin

_____ Other

9. **Please rank from 1 to 8 (1 is most important)** the following reasons your child attends the African Cultural Program.

_____ Keep busy after school _____ Get free computer at home

_____ Learn about the African culture _____ Make friends

_____ Communicate with children in Africa _____ Learn science

______ Get free Internet at home _____ Learn how to use a computer

10. Please feel free to share any other feedback you have about the African Cultural Program.

11. **If you have a computer at home, please answer A, B, and C below.**

A. In what room/s is/are the computer/s located?

____

B. Do you have Internet access at home? _____ Yes _____ No

C. How does your family use the computer? **Please check all that apply.**

_____ Learning about current events

_____ Banking / Investing

_____ Homework

_____ E-mail

_____ Buying goods and services

_____ Getting medical information

_____ Participating in online discussion groups

_____ Job hunting

_____ Playing games

_____ Getting general information

THANK YOU FOR COMPLETING OUR SURVEY!

Appendix H

Do You Think It Will Rain Today? Implementation Plan

Do You Think It Will Rain Today? Implementation Plan

<u>Setting the Scene</u>

Objectives: Determine students' pre-existing knowledge regarding the water cycle.

Determine local, cultural knowledge regarding the water cycle.

Set the stage to investigate how scientists explain rain.

Learners process preliminary ideas and generate questions.

Learners share ideas with cross-cultural cohorts.

Activity: Implement (Keogh & Malcolm, 2004, p.8-10).

Share sorted preliminary ideas and question bank with cross-continental cohorts via group e-mail.

Learners compare and contrast shared information.

Investigation

Objectives: Provide hands-on inquiries for learners to investigate the water cycle.

Learners determine relationships between cultural beliefs and scientific ideas about weather, adaptation and survival.

Activity: Implement (Keogh & Malcolm, 2004, p.8-10 and 24-26).

Relate Q4 (p.16) to local weather patterns and the water cycle.

U.S. learners examine names of months in English and African learners examine names of months in Zulu to determine if relationship exists between title of month and common weather patterns (p.23).

In small groups and large group discussion, learners contemplate animal and plant adaptations and local, cultural language and knowledge about those adaptations (p.24-26).

Communicate findings and their application with cross-cultural cohorts.

Compare and contrast various cross-cultural knowledges.

Can We Make Rain?

Objective: Learners examine contradictions and similarities between different epistemologies.

Activity: Implement (Keogh & Malcolm, 2004, p.26-28).

Learners write letter to cross-cultural cohort that answers the following questions:

How do some people decide if it will rain?

What does the water cycle have to do with rain?

What is my own, personal belief about how rain happens?

Do You Think It Will Rain Today? Implementation Plan

I. Setting the Scene

Objectives: Determine students' pre-existing knowledge regarding the water cycle.

Determine local, cultural knowledge regarding the water cycle.

Set the stage to investigate how scientists explain rain.

Learners process preliminary ideas and generate questions.

Learners share ideas with cross-cultural cohorts.

Activity: Implement (Keogh & Malcolm, 2004, p.8-10).

Share sorted preliminary ideas and question bank with cross-continental cohorts via group e-mail.

Learners compare and contrast shared information.

Text below from Keogh, M. & Malcolm, C. (2004). Do You Think It Will Rain Today? p. 8-10.

PART ONE: SETTING THE SCENE.

Gugu introduced the module by asking the students to say whether or not they thought it would rain today. Students looked out the window, and offered their opinions, with reasons. The class talked about some of those opinions – the presence of cloud, lightning, the time of the year, the behaviour of birds…. Gugu chose not to take the discussion too far at this stage. Instead, she explained how the class would explore the question over the next few weeks, including the nature of rain, how rain formed, and patterns that told us it might rain soon. Gugu gave the class a homework task: to ask people at home how they would decide whether it might rain today. Each student should ask six people – four older people and two young people. They should write down who they asked and what each one said. She gave them two days to do this.	*This opening has two primary purposes: to introduce the module (setting the agenda for it) and to get students involved.* *The question is an 'inclusive' one – one to which everyone can contribute, and which has wide natural interest.* *The suspension of the classroom discussion to set up the homework exercise signals that the module is interested in local, cultural knowledge, not just 'scientific' knowledge.* .
She turned back to class work. In the earlier discussion, everyone had recognized that clouds were necessary for	*It was clear, from classroom discussion, that the students knew that*

rain: clouds must contain rain. The class would explore this. In groups of four, she asked them to draw two pictures, explaining the groups ideas about: • How /why water gets into clouds • How/why rain falls from clouds She gave them large sheets of paper to draw on. When they had finished, they stuck their pictures on the wall. She invited students, from the pictures, to identify some of the common ideas, and some uncommon ones. She summarised ideas under the two headings, how/why water gets into clouds, and how/why it comes out. At this stage, it was more important to bring in all ideas than to judge them: there would be time for that later. As they made the summary, she asked students to write down questions that the summary raised. These were then put onto a big piece of chart paper, as the beginning of a question bank. During the course of the module, they would seek to answer these questions and add more. Some of their questions are listed in Fig 1.	*clouds were an essential sign of rain. Gugu wanted to build on their knowledge, exploring their ideas. By whole-class discussion a community of knowledge could develop, and challenge students' individual thinking.* *By asking students to draw pictures, Gugu was able to get information efficiently, by looking over students' shoulders, about their understanding. By not judging their ideas, she was true to her intentions to spend the whole module, not just today, finding better answers.* *The question bank too was a way of including all students' concerns. She had to be sure that she returned to this, and genuinely used it as in input to the module.*

Our questions about rain.

How do the waterdrops get into the sky
When does the water get there?
Why can't we see the water in the air?
How much water is there in the air?
How does the Rain Queen make rain?
Why do small frogs come out on the road when it rains?
How can it be raining in one place and not in another?

Fig 1. The beginning of a question bank about rain.

The students brought to the next class their homework. She asked students to report quickly and briefly on some of the different ideas, and whether young people or older people had offered them. Her intention at this stage was simply to	*Students had already talked about their own ideas. What was new was what people in their communities felt.*

canvass the variety of answers. Then she proposed that they classify the answers as part of more detailed reporting. Based on ideas already presented, she made four headings: • Patterns in the sky • Patterns in time and space • Plant and animal behaviours • Gods and spirits The students, as they reported, looked especially for ideas that were not yet on the list, and talked briefly about what those ideas meant. They also kept track of ideas raised frequently. When the reports were finished, Gugu invited students to extend the list, by imagining themselves in other places, such as deserts, jungles, mountains and out in the ocean. Would the amounts of rain be the same? What might the signs of rain be? From the blackboard, students made lists in their notebooks. Parts of the lists are shown in Fig 2.	*Sorting the information under headings served two purposes: it required students to process the ideas they had found, and it set up topics and a structure for the rest of the module.*

Patterns in the sky

The wind is blowing from the South.
There are big black clouds.
Clouds are moving in from the sea.
The wind is stronger and has changed direction

Animal and plant behaviours

When we see flying ants
When the frogs come
When the whit e irises flower

Patterns in Time and Space

It often rains in the afternoon.
Never in July
It was raining yesterday

Gods, omens and spirits

The gods are angry
We have conducted a ritual for the gods
The king visited our village yesterday

Fig 2. Some patterns and signs that suggest rain, grouped under headings.

Gugu explained that in the rest of the module, the class would explore ideas from all the boxes, and try bringing them	*Gugu is making it clear that the central focus of the module is the way that*

together, to better understand what caused rain, and patterns that indicated rain. They would focus especially on the ways that scientists explained rain. She noted that scientists have only come to understand rain and weather patterns in the last 100 years or so – assisted greatly by new technologies to gather weather information over large areas. These included telephones (to report on whether in different places), computers to analyse weather records and conditions, and camera-carrying satellites that take photographs of earth from out in space. She showed them some pictures to illustrate (See Fig 3)	*scientists explain rain. Even so, she wants to relate that to local knowledge.* *Her reference to the recent development of science (not only in regard to weather) and its dependence on technology is not merely interesting truth: it is culturally sensitive, pointing to research capacities not available to most communities.*

II. Investigation

Objectives: Provide hands-on inquiries for learners to investigate the water cycle.

Learners determine relationships between cultural beliefs and scientific ideas about weather, adaptation and survival.

Activity: Implement (Keogh & Malcolm, 2004, p.8-10 and 24-26).

Relate Q4 (p.16) to local weather patterns and the water cycle.

U.S. learners examine names of months in English and African learners examine names of months in Zulu to determine if relationship exists between title of month and common weather patterns (p.23).

In small groups and large group discussion, learners contemplate animal and plant adaptations and local, cultural language and knowledge about those adaptations (p.24-26).

Communicate findings and their application with cross-cultural cohorts.

Compare and contrast various cross-cultural knowledges.

Text below from Keogh, M. & Malcolm, C. (2004). Do You Think It Will Rain Today? p. 15-16 & 24-26.

WS1 Where does the water go to?

Complete this activity working in you 'expert group'.

You will use the following words:

Evaporation – water changing from a liquid to a gas
Condensation – water changing from a gas to a liquid
Humidity – a measure of how much water vapour there is in the air. We say the air is humid when it contains a lot of water vapour. We feel hot and 'sticky'.
What Zulu words or phrases might you use for these?

You are going to pour some hot water into one jar, some cold water into another, and cover each one with a cold plate. The plates should be as cold as possible. You can do this by keeping them in cold water from the tap until you need them, then dry them and put them on the jars.

You will need: A supply of very hot water and a supply of cold water.
2 glass jars, such as coffee jars,
2 plates to cover the top of the jars.

A watch or clock

First, make predictions:
1. Discuss with others in your group what you think will happen, the order that things will happen and how long you think they will take. Make a record of your predictions in your notebook.

Then do the experiment:
2. Pour the hot water into one jar until it is half full and immediately place the plate on top. At the same time have another member of the group add the same amount of cold water to another jar.

<< Glass jar half full of water, with plate on top X2, one with hot water and one with cold>>

3. Record your observations in the order in which they happen. Use a table, like the one below.

Time	Hot water	Cold water
0 mins	We poured the hot water in.	We poured the cold water in.
	The air went cloudy/misty	
	The sides of the jar got wet, drops of water on them.	
	My hand felt warm and humid	
	There were drops of water on the plate	
	Drops of water started running down the sides of the jar	

4. After three minutes take the lid of and put your hand in for a while.
What does it feel like?

5. Continue recording your observations until there are no more changes.

Questions

Q1.How good were your predictions? Explain?

Q2. Why do we need to have two jars? What does the difference between the two jars tell you? *(That whatever is happening in there has something to do with the temperature of the water.)*

Q2. What do you think is in the air above the hot water? Above the cold water?

Q3. What causes the water droplets on the hot water jar and on the plate?

Q4 From this experiment what can you say about the conditions necessary for evaporation and for condensation.

PART FIVE: ANIMALS, PLANTS AND THE WEATHER

Many animals and plants change their behaviour when it is about to rain. Students had listed some of these patterns at the start of the Module. Gugu reminded them of their suggestions, and asked them to read out the full list they had made. Could we explain how plants and animals can be sensitive to changes in the weather, and change their behaviour when a change is due? She asked the students first to think about what animals needed to do in order to live (and their students live). Students soon put together a long list, including eat, drink, breathe, shelter, grow, reproduce, excrete and respond to their environment. She asked them whether this list also applied to plants, and the students felt that it mostly did, but in different ways. It was the last idea that Gugu asked them to think more about: responding to the environment. Eating, finding	*In Part Four, students connected their local knowledge to scientific data on seasonal patterns in rainfall.* *Here she wanted to make links with other formal knowledge from science classes. She signalled this intention by asking them to recall the characteristics of living things.* *She then shifted attention to the ways living things respond to stimuli, as a way of enhancing their survival.* *She starts with humans, and extended to plants and animals.* *She wants students to think*

shelter (from weather and other dangers),and reproducing all depended on the environment. Gugu asked the class to suggest some signals, or stimuli, that people pick up from the environment and how they respond to them. The students suggested things like: • we know when it cold: we put on a jersey. • when its getting dark; we light the lamp. • when we see a car coming, we stand off the road. • When we see a boy/girl who we might like for a boyfriend/girlfriend, we smile and try to look our best. Gugu helped them to understand that the responses we make to particular stimuli are to help us (and our species) survive in our environment. They are part of the way we are *adapted* to our environment. To extend this idea, she asked them, in groups, to make two lists: one of stimuli in the environment that plants would respond to and one of stimuli that animals (other than humans) would respond to. She wanted them to list stimuli especially that might be related to or affected by the weather. For each stimulus they listed, they were to say how responding to that stimulus would help the animal or plant to survive, and how that could tell us about the weather. She gave the class one example to start them off.	*about stimulus-response as cause-effect, and speculate (hypothesise) reasons in terms of survival of species.* *Because she wants to bring in a wide range of ideas, she uses small group discussions followed by whole class discussion.*

Animals respond to these things in their environment:
Animals: Flying ants
Stimulus: the air is humid or wet.
Response: flying around.
Reason: Flying ants need water to breed and set up new colonies so they only fly when the air is wet, this often means it is going to rain.

After ten minutes, she led a discussion of the ideas the students had suggested, first for animals, then for plants.	*Gugu wanted now to bring into the classroom community knowledge, which*

The students could see that many of the behaviours they had described were signs that there would be a change in the weather. Gugu asked the students to go and find out from older people any other signs that animals and plants can give about changes in the weather, and, if possible, how that behaviour helps the animals and plants survive. She reminded them that many Zulu sayings refer to animal behaviour as signs of weather. For example, *ku-Kahlele uHlalwane ko-Ba yi Ndladla*. (The Isoglossa has flowered, so there will be a famine). Some plants that live in very dry places, such as the isoglossa, produce their flowers, and therefore seeds, as a response to the stress of dry conditions. This helps the species survive, because the seeds can stay dormant in the soil until the rains come again. She told them that, from the homework, they were going to choose some ideas to write about and perform a short play. The students came back to class with a lot of information and sayings they had collected. They shared the information with the others in their group, and talked about ways in which animal behaviours related to survival and to changes in weather. Gugu asked each group to choose one of their examples to write up and present as a short, (3-4 minutes) play. The play should tell the other groups: • what the plants/ animals did • why (if possible) • what this indicates to people about the weather. Gugu worked with the groups as they made their selections, to ensure there was a variety of examples, and that the students knew what to do. The students presented their plays. They were delighted to find out how well their cultural sayings and ways of predicting the weather linked with the scientific ideas of sensitivity to the environment, adaptation and survival	*students could then examine from the scientific framework of stimulus-response and survival.* *She asks them to express their ideas in a role play. This not only enriches the variety of communication modes in the classroom; it is well suited to talking about the behaviours of plants and animals.*

III. Can We Make It Rain?

Objective: Learners examine contradictions and similarities between different epistemologies (knowledges, ways of knowing).

Activity: Implement (Keogh & Malcolm, 2004, p.26-28).

Learners write letter to cross-cultural cohort that answers the following questions:

How do some people decide if it will rain?

What does the water cycle have to do with rain?

What is my own, personal belief about how rain happens?

Text below from Keogh, M. & Malcolm, C. (2004). Do You Think It Will Rain Today? p. 26-28.

PART SIX: CAN WE MAKE RAIN?

The class turned attention to the remaining set of patterns that can be signals of rain: the intervention of omens, gods and spirits. Gugu suggested to the students that these signs were more about *making* rain, than predicting rain. In all cultures, but especially those situated in dry climates, people have sought ways to make rain, through mind-control, the involvement of gods and spirits, special rituals, chemicals, prayers and omens. Gugu took the students back to the list they had made at the start of the Module. Together the students read through the list, talking about how strategies as ways of making rain, rather than predicting it.	*Gugu has a number of important objectives in this segment:* ○ *to set science into the larger field of human actions and purposes* ○ *to allow ideas of culture and deep traditional knowledge to take centre stage in the discussion* ○ *to explore some of the ways in which scientists test their theories, and the difficulties of conducting and interpreting the tests*
Gugu asked students to draw pictures showing a chosen ritual or practice. Then they presented some of the pictures to the rest of the class, explaining how and whether they worked. Gugu explained that scientists too, in many countries, had sought to 'make rain'. She said she would tell them what scientists do, and she wanted the students to make notes at the end of the story. She wrote on the board three	*Gugu asks the students to present stories of traditional rain-makers through pictures. She then presented scientists' efforts also as a story, told orally. She wanted to find a resonance with the students' stories.* *To help the students identify the key points in the story,*

questions, to help them with their listening: • Do scientists try to make rain when there are no clouds? • What methods do they use to increase the rain from a cloud? • How do they test whether their methods have succeeded?	*she puts some guiding questions up first.* *If the students still have trouble, she might tell the story again, or get one of the students to tell it.*
Then she told the story. *Scientists in many countries around the world, including South Africa, have tried to make rain. They don't try at times when there are no clouds in the sky, and they don't try with clouds that are not rain-clouds. They only work with clouds that are close to raining, likely to rain soon anyway. They try not so much to make rain as to increase the rain those clouds produce.* *They use two methods, both related to the water cycle.* *1. They try to increase the condensation of water vapour in the cloud. They can do this by adding chemicals to the cloud that either lower the temperature in the cloud, or provide tiny particles onto which droplets can condense, like breath on a mirror.* *2. They try to increase the joining together of small droplets into big droplets within the cloud, which then fall as rain. They can do this by adding to the cloud chemicals that attract droplets of water.* *Have these methods been successful at 'making rain'? It's not easy to tell. The methods only work for clouds that are close to raining, or bound to rain anyway. To test their methods, scientists have to decide whether the cloud made more rain than it would have otherwise. But they don't really know what would have happened if the cloud hadn't been treated.* *One test is to look for two clouds that are close to raining, in the same area and very similar to each other, then add chemicals to one but not the other. It's not easy to get two clouds that are 'very similar' like that, and ready to rain. Scientists use many different instruments and measurements to see if the clouds are close to raining, and how similar they are.*	*The story, as she tells it, draws strongly from the students' earlier studies of the Water Cycle.* *It focuses on the difficulty of scientific tests in situations such as this, and offers two alternatives – the controlled experiment (which students already know about for Part Thee, and other work they have done in Science), and long term weather patterns (which they discussed in Part Four).* *This focus on testing sets up the next activity, where they think about ways to test traditional rain-making methods.*

Another test of their methods is to add chemicals to all rain clouds in an area for a (usually rainy) month, and see if the rainfall is then greater than it was in earlier years. This test is not easy either, because scientists don't really know how much rain would have fallen without the treatment. *In spite of the difficulties of the tests, and the difficulties of deciding whether it is worth treating a particular cloud, scientists believe they have had a lot of success – increasing the rain from particular clouds by about 25% - 40%. However, the increase is only possible during the wet season – when suitable clouds are already there. Then it becomes necessary to save that water for the dry season.* Gugu invited the students to ask questions about the story, or discuss some of the difficulties. Then she asked them to make their own notes, using the questions on the board to guide them. She gave them a lot of time to make their notes, and moved around the room to give help.	
Gugu asked the students to think about the ways, in African culture, people tried to make rain. She used as the basis for the discussion the pictures they had drawn and two of the three questions she had asked earlier: • Do people try to make rain when there are no clouds? • How do they test whether their methods have succeeded? The class talked especially about the difficulties of testing whether the methods were successful: would it have rained anyway? How could you tell whether the methods produced more rain than would have fallen anyway? Gugu wanted to leave open for the students to decide what they believed about rainmaking. To do this she set them a writing task: *You have just received a letter from a friend who has studied the same module we have just done. The friend says she enjoyed learning about the water cycle, how complicated weather is, and how scientists have tried to make rain. But, the friend says, she still thinks traditional practices can influence the water cycle, and make rain.* *What do you think? Write her a letter explaining your*	**The students apply their learning from the scientists' story to their knowledge of African rain-makers.** *The discussion brings students face to face with the nature of science, and scientific testing, but seeks no overall judgement of African methods. Instead, students make personal reflections, by responding to a letter from a friend.*

position. Gugu did not collect the letters, or read any of them out to the class – if the students wanted to compare their beliefs, they could do it as they pleased, outside the class.	

Appendix I

Do You Think It Will Rain Today? Stage One United States Learners

WILL IT RAIN TODAY? CLUES USED BY yfc BEGINNER CLASS

The AIR

Smell MOISTURE IN THE AIR

Air feels thick
Air is foggy
Air is cold
Notice how fast the wind blows
it is windy
static electricity

plants & animals

the grass is moist
trees will move
dog starts barking
dogs' hair stands on end with thunder & lightning
geckos hide under leaf during thunderstorm
cats & dogs come in house
horses act scared – neigh and thrust backward

what people say & do

LOOK AT THE NEWS
LISTEN TO RADIO FOR WEATHER REPORT
MY M0M SAYS THE CORNS ON HER FEET HURT
A GUY SAYS HIS LEGS SWELL AND HIS JOINTS SWELL
I GET A HEADACHE
I START SNEEZING FROM THE POLLEN
MY ELBOW ITCHES
IT GETS HARD TO BREATHE BECAUSE THE AIR IS THICK
POWER GOES OUT
MY COUSIN'S EYES CHANGE COLORS WHEN IT RAINs

THE CLOUDS & SKY

LOOK FOR BLACK RAIN CLOUDS

LOOK FOR GREY CLOUDS
Sky will be dark
it could be sprinkling
sounds – rumbling & thunder
lightning

OUR QUESTIONS

Why does rain appear? What are the chemicals in rain? Is it just water?
How long does it take to rain? How does rain form?
How long does rain stay in one area? Why does rain form?
In Africa, do you use rain water to drink? Do you boil it to sterilize it, then use it?

Do You Think It Will Rain Today? Stage One United States Learners

WILL IT RAIN TODAY?
CLUES USED BY HHBGC BEGINNER CLASS

USING THE MEDIA
THE WEATHER CHANNEL
CALL THE TIME PHONE #

ASK JEEVES
CALL THE WEATHER
TV GUIDE CHANNEL
LOOK AT THE NEWSPAPER
RADIO

THE SKY
IF THE SKY IS DARK
IF THE SKY IS BLACK AND YOU DON'T SEE CLOUDS
LIGHTNING
THUNDER

PLANTS & ANIMALS

LOOK AT THE ANIMALS
IF DOGS & SNAKES RUN AWAY, IT WILL RAIN
BIRDS FLY AROUND
IF THE TREES MOVE BACK AND FORTH, IT WILL RAIN

THE AIR

WHEN IT GETS COLD AND WINDY

WHAT PEOPLE SAY & DO

STORES SHUT DOWN SO THE STAFF DOES NOT GET CAUGHT IN THE RAIN.
YOU HEAR SIRENS.
LICK YOUR FINGER AND PUT IT IN THE WIND. THEN IF THE WIND BLOWS ONE WAY, IT WILL RAIN. IF THE WIND BLOWS ANOTHER WAY, IT WILL NOT RAIN.
MY GRANDAPA SAYS HIS KNEE HURTS.
MY GRANDMA SAYS YOU BETER GO HOME BECAUSE IT'S ABOUT TO GET BAD OUT HERE.
MY GRANDMA SAYS HER TOE GETS SWOLLEN.
YOU HEAR WIND CHIMES.

OUR QUESTIONS ABOUT RAIN

WHAT IS RAIN?
HOW DOES IT RAIN?
WHY DOES THE CLOUD HAVE TO FILL UP WITH WATER BEFORE IT RAINS
WHY DOES IT RAIN?
WHY DOES RAIN HAVE SALT IN IT?
YOU KNOW HOW THE WATER EVAPORATES, THEN IT CONDENSES, THEN IT PRECIPITATES – IS THAT THE SAME RAIN OVER AND OVER AGAIN?

Do You Think It Will Rain Today? Stage One United States Learners

WILL IT RAIN TODAY?

CLUES USED BY YFC ADVANCED CLASS

PLANTS AND ANIMALS
Grass might be moist.
When the leaves on trees flip over, a swirling wind pushed the trees.
Cats go in the house.
Birds fly away.
Birds go to their nests.
Birds act hyper.
Horses get jittery.
Dogs' fur smells.
Gerbils start chewing on their cage.

THE AIR
Wind is moist, won't be dry.
The air will smell funny.
It will get colder.
The air will get more humid.

THE SKY
Cloudy sky
The sky will be darker

WHAT PEOPLE SAY AND DO
My Grandmother's knee starts hurting.
Traffic slows down.
I get tired.
My Grandma starts to get cramps in her feet or hands.

Appendix J

United States Advanced Class Letter Do You Think It Will Rain Today? Stage One

Dear Zwelethu cohorts,

What is a Sangoma? We think it means drum and dance. Najma says what the Sangomas do is science because science is observing and predicting what is going to happen and continuing to do the test until you get it right. If you don't get it right, you try again. Brandonne, Barahka, Briana and Christopher say the Sangoma will do a rain dance when it is dry and the crops need rain. Najma and Adiyah say the Sangoma will check to see if it looks like it's going to rain. The Sangoma will look for cloudy skies. Christopher says it's science in a way because it is motion and dance.

We have native American Indian tribes in the United States. The tribes have different names like Sioux, Navajo, Cherokee, Creek and Aztec. Briana's great grandmother was Cherokee. The native Americans were here before the Europeans like Christopher Columbus came. Native Americans have rain dances also.

We are talking about why animals change their behavior when it is going to rain. Here are our reasons:
They don't like the rain.
They interact with the environment.
Animals have instincts to read their environment. Like birds can tell when it is getting colder here and close to winter, so they fly south to a warmer area.
When Briana lived in Florida with her Grandmother, when it is about to rain, red ants would go in the pipes. When they turned the water on, red ants would come out.
Brandonne says the way animals are made and the way they act in response to the environment is called an adaptation.

We are thinking of English words or sayings that name an animal's or plant's behavior.
Nocturnal means an animal is awake at night, like the owl.
Photosynthesis is how a plant makes its own food using the energy from the sun.
Photo means light and synthesis means to make.
Catfish are a fish that has whiskers like a cat.
Sunflowers look like the sun and always turn toward the sun.

From your United States cohorts,
Barahka, Adiyah, Briana, Kiasia, Serwa, Ericca, Najma, Steven, Timothy, Dominic, Phillip, Christopher and Brandonne Ms. Kathleen and Ms. Robin

United States Beginner Class Letter Do You Think It Will Rain Today? Stage One

Dear Ainsworth Cohorts,

What is it like living near the Equator? It is autumn here now. Autumn comes right before winter. Tess says it is hot and cold at the same time now. It is kind of cold in the morning and at night. It gets warm during the day.

Shaka wants to know why the countries on the Equator have only 2 seasons, wet and dry. Chloe and Ayanna think it is your rainy season now. Is it?

Nicholas says Native Americans are the people who were here when Christopher Columbus came. Aaron says the Native Americans were the first people here. Tyler says watching nature and the environment was important to Native Americans so they could know when to plant their crops.

Nicholas says Native Americans practiced science because they watched things and recorded information so they know how to plant. They probably recorded how the plants grew. Ayanna says she studies the environment to decide if it will rain and that is science. Jordan says if someone gets information and watches for information and says it is going to rain, they are not causing it to rain. But, they are predicting rain.

Ahsante for being our penpals,
Ronika, Jordan, Shaka, Ayanna, Stanley, Nicholas, Aaron, Brandon, Tyler, Caleb, Eric, Chloe, Jasmine, Tess, Laron, Charrae, and Sharifa
Mr. Orange

Appendix K

United States Beginner Class Do You Think It Will Rain Today? Stage Two

WS1 Where does the water go? STC GROUP YFC BEGINNER

Complete this activity working in you ‘expert group’.
You will use the following words:
Evaporation – water changing from a liquid to a gas
Condensation – water changing from a gas to a liquid
Humidity – a measure of how much water vapour there is in the air. We say the air is humid when it contains a lot of water vapour. We feel hot and ‘sticky’.
****What Zulu words or phrases might you use for these?*

Hot, sticky, I’m burning up, Sweaty, Musty (What people around here say)
****

You are going to pour some hot water into one jar, some cold water into another, and cover each one with a cold plate. The plates should be as cold as possible. You can do this by keeping them in cold water from the tap until you need them, then dry them and put them on the jars.

You will need: A supply of very hot water and a supply of cold water.
2 glass jars, such as coffee jars,
2 plates to cover the top of the jars.

A watch or clock

First, make predictions:

1. Discuss with others in your group what you think will happen, the order that things will happen and how long you think they will take. Make a record of your predictions in your notebook.

***Our predictions:
The hot water will fog up the glass.
The water will evaporate to the plate.
The hot water will turn to vapor.
When you take the lid off the hot water, steam will come out.
The hot water will make mist. The cold water will stay clear.
The cold water will get warmer.

Then do the experiment:

2. Pour the hot water into one jar until it is half full and immediately place the plate on top. At the same time have another member of the group add the same amount of cold water to another jar. << Glass jar half full of water, with plate on top X2, one with hot water and one with cold>>

United States Beginner Class Do You Think It Will Rain Today? Stage Two

3. Record your observations in the order in which they happen. Use a table, like the one below.

Time	Hot water	Cold water
0 mins	We poured the hot water in the jar.	We poured the cold water in the jar.
1min.	Water vapor in glass	Glass feels cool.
2 min.	Water vapor is swirly.	No water on plate
3min.	Drops of water on plate.	Looks the same

4. After three minutes take the lid of and put your hand in for a while.
What does it feel like?
It was real hot. The hot water was warm.

5. Continue recording your observations until there are no more changes.

Questions

Q1.How good were your predictions? Explain.
Our predictions were good because the plate did have water on it. Steam came up like the mist predicted. The cold water stayed clear.

Q2. Why do we need to have two jars? What does the difference between the two jars tell you?
One had hot water and one had cold water.

Q2. What do you think is in the air above the hot water? Above the cold water?

Steam is in the air above the hot water. Oxygen is in the air above the cold water.

Q3. What causes the water droplets on the hot water jar and on the plate?
The heat from the water made condensation on the plate.

Q4 From this experiment what can you say about the conditions necessary for evaporation and for condensation? Water has to go in the air for evaporation to happen. Heat helps the water evaporate more quickly. For condensation to happen, the evaporation from the water has to go up to the plate. Water in the air has to come into contact with cold to condense into droplets.

United States Beginner Class Do You Think It Will Rain Today? Stage Two

WS1 Where does the water go? ***STC Group_ HHBGC beg__***

Complete this activity working in you 'expert group'.
You will use the following words:
Evaporation – water changing from a liquid to a gas
Condensation – water changing from a gas to a liquid
Humidity – a measure of how much water vapour there is in the air. We say the air is humid when it contains a lot of water vapour. We feel hot and 'sticky'.
*******What Zulu words or phrases might you use for these?***

Our English words and phrases:
I'm burning up. It's hot. I'm sweating. You can fry an egg on this sidewalk.
****
You are going to pour some hot water into one jar, some cold water into another, and cover each one with a cold plate. The plates should be as cold as possible. You can do this by keeping them in cold water from the tap until you need them, then dry them and put them on the jars.

You will need: A supply of very hot water and a supply of cold water.
2 glass jars, such as coffee jars,
2 plates to cover the top of the jars.

A watch or clock

First, make predictions:

2. Discuss with others in your group what you think will happen, the order that things will happen and how long you think they will take. Make a record of your predictions in your notebook.

***Our predictions:
The cold water will sweat.
The hot water bottle will get softer.
The hot water bottle will get sweaty and fog up.
Condensation will happen in both bottles.
Water will get up on the plate in the cold bottle.

Then do the experiment:
2. Pour the hot water into one jar until it is half full and immediately place the plate on top. At the same time have another member of the group add the same amount of cold water to another jar.
<< Glass jar half full of water, with plate on top X2, one with hot water and one with cold>>

United States Beginner Class Do You Think It Will Rain Today? Stage Two

3. Record your observations in the order in which they happen. Use a table, like the one below.

Time	Hot water	Cold water
0 mins	We poured the hot water in the jar.	We poured the cold water in the jar.
1min.	**Nothing**	nothing
2 min.	*Plate is hot. Bottle is hot.*	Plate is cold. Bottle is cold.
3 min.	*Steam on the inside*	Nothing
4 min.	*Plate has water on it.*	Plate is dry.

4. After three minutes take the lid off and put your hand in for a while.
What does it feel like?
Hot, steamy in hot water bottle. Cool in cold water. .

5. Continue recording your observations until there are no more changes.

Questions

Q1.How good were your predictions? Explain.
Water got on the plate in the hot water bottle, not in the cold water bottle.
The cold water bottle did not sweat

Q2. Why do we need to have two jars? What does the difference between the two jars tell you?
One had hot water and one had cold water. The hot water bottle did more.

Q2. What do you think is in the air above the hot water? Above the cold water?
Water evaporated into air above hot water. Don't know about cold water.

Q3. What causes the water droplets on the hot water jar and on the plate?
The water was hot and evaporated into the air. When the water in the air hit the plate, it condensed into droplets.

Q4 From this experiment what can you say about the conditions necessary for evaporation and for condensation? Hot water evaporates more quickly than cold water. When the water vapor gets colder or hits something cold, it turns back into liquid water.

United States Advanced Class Do You Think It Will Rain Today? Stage Two

WS1 Where does the water go? ***YFC ADVANCED CLASS*** _________

Complete this activity working in you ‘expert group’.

You will use the following words:

Evaporation – water changing from a liquid to a gas
Condensation – water changing from a gas to a liquid
Humidity – a measure of how much water vapour there is in the air. We say the air is humid when it contains a lot of water vapour. We feel hot and ‘sticky’.
What Zulu words or phrases might you use for these?

You are going to pour some hot water into one jar, some cold water into another, and cover each one with a cold plate. The plates should be as cold as possible. You can do this by keeping them in cold water from the tap until you need them, then dry them and put them on the jars.

You will need: A supply of very hot water and a supply of cold water.
2 glass jars, such as coffee jars,
2 plates to cover the top of the jars.

A watch or clock

First, make predictions:

3. Discuss with others in your group what you think will happen, the order that things will happen and how long you think they will take. Make a record of your predictions in your notebook.

Our predictions:
Steam
Plastic will melt
When we put the lid on, the water will evaporate.

Then do the experiment:

2. Pour the hot water into one jar until it is half full and immediately place the plate on top. At the same time have another member of the group add the same amount of cold water to another jar.

<< Glass jar half full of water, with plate on top X2, one with hot water and one with cold>>

United States Advanced Class Do You Think It Will Rain Today? Stage Two

3. Record your observations in the order in which they happen. Use a table, like the one below.

Time	Hot water	Cold water
0 mins	We poured the hot water in the jar.	We poured the cold water in the jar.
30 seconds	**Jar was plastic, started to melt.**	Jar stayed the same.
1 minute	*Jar steamed up.*	No steam
1 minute 30 second	*The steam swirled and went in another direction.*	Stayed the same.
2 minutes	*Jar got cloudier.*	Stayed the same.
3minutes	*Some of the water evaporated.*	Did not evaporate.

4. After three minutes take the lid of and put your hand in for a while.
What does it feel like?

5. Continue recording your observations until there are no more changes.

Questions

Q1.How good were your predictions? Explain?
They were ok.

Q2. Why do we need to have two jars? What does the difference between the two jars tell you?
Jars were the same. One had hot water, one had cold water.

Q2. What do you think is in the air above the hot water? Above the cold water?
The air above the hot water got misty because of the steam. The air got hotter.
The air above the cold water stayed the same.

Q3. What causes the water droplets on the hot water jar and on the plate?
The heat might make the water evaporate.

Q4 From this experiment what can you say about the conditions necessary for evaporation and for condensation?
Evaporation – water or a liquid absorbs heat and goes into the air. The water becomes a gas.

Condensation – the liquid or solid comes in contact with hot air. The air gets colder and the water vapor in the air condenses into liquid drops.

Appendix L

United States Learner Letters Do You Think It Will Rain Today? Stage Three

Dear MY COHORT,

My name is Barahka. I think we can't make it rain because we don't I don't think it is possible. I think some people decide if it is going to rain because the sky is dark. The water cycle has to do with water because than what is the point for evaporation. I think my belief is because god thinks the plants need rain. I want to know how to pronounce your last name. I have a six-year-old brother.

Barahka Kariamu

United States Learner Letters Do You Think It Will Rain Today? Stage Three

Help

Reply Reply to all Forward

From: USA LEARNER   Sent: Tue 12/7/2004 6:25 PM
To: vzakheprincipal@mweb.co.za
Cc: UMSL, nascep_3; asb27@yahoo.com
Subject: Rain Questions
Attachments:

View As Web Page

Hi Zinhle,

This is your pin pal Ashley. These are some of the questions that I am supposed to answer and send to you. The letter Q stands for question and A stands for answer. I hope that you understand this very much.

Q. Can we make it rain? If yes, how?
A. No, we can't make it rain. Rain will come down from the sky when it is ready.

Q.How do some people decide if it will rain?
A. Meteorologists (weather people) decide when it will rain by looking at the sky and judging the cloud cover and also using scales, barometers, thermometers, and satelites.

Q. What does the water cycle have to do with the rain?
A. The water cycle has alot to do with the rain. The first step is precipitation. The next step is condensation and the next step is evaporation.

Q. What is my own, personal belief on how rain happens?
A. My own opinion is that the only one who can make it rain is Jesus.

Q. Is there any thing else that you would like to talk about to your pin pal?
A. You ask me the questions.

Now it is your turn to ask the questions and answer the same ones that I have given to you. Please e-mail me back. I haven't had a letter from you since I have started.

Until we meet again,
Theresa

Appendix M

South African Learner Letters Do You Think It Will Rain Today? Stage Three

Hi Najma.

ancestors for a rain .So we can make it rain by communicating with ancestors .

HOW DO SOME PEOPLE DECIDE IF IT WILL RAIN ?
Usually they look to the sky and see the clouds condition ,if they are darker those are the signs rain .Some people determine by seeing the plants behaviour like sunflower ,it closes when there rain coming .

WHAT DOES THE WATER CYCLE HAVE TO DO WITH RAIN?
When the dams,lakes,ocean,etc are heated by the sunrays they'll form the water vapour (steam or gas) ,than the evaporation process takes place .A fact is that warm air rises and cold air sinks . I'm so glad that I'm going to explain to you about the rain and it factors.I have five questions that I'm going to explain for you.

CAN WE MAKE IT RAIN ? IF YES HOW?
In our culture we that if it is not raining for long period ,we berg for the rain .We use to go to the mountain and do some sacrifices including slaughter a cow and pray to
When this steam rich to the cold space or place it will become cold and form clouds , they'll fuses and the condensation process takes place .Once the drops of water fused together they will become heavy the rain will be released .

WHAT IS MY OWN PERSONAL BELIEF IN HOW RAIN HAPPENS?
My belief is that in order to have rain there must be an enough evaporation occurring and lot of warm air to rise so that it will rich to the cold space and become cold and form a clouds and small drops of water than they will fuse together and form dark clouds and release the rain .

I would like you explain from the information of yours or any , about why there is lot of sound heard and lightning when there is thunder storm .
And can you explain any media where you get information about weather .

South African Learner Letters Do You Think It Will Rain Today? Stage Three

SOME PATTERNS AND SIGNS OF RAIN

Hi Phillip,

I would like to tell you about patterns and signs of rain in our country I can say that we can make rain. Well here in South Africa we have the so called isangoma's who are called (witch doctors) and they have spirits and beliefs on their ancestors (the late ones). And we all know that beliefs don't just come out from the blue there's a belief for a reason. For example if you people in America a certain race believes that if they have a rain dance in order for them to get the rain they need then definitely its going to rain. So here in South Africa it is possible to make rain.

Well most people will say they look at the sky to search if there are any clouds and when clouds collide they form rain. And the other one is by the understanding your water cycle and the moist in the air (humidity) can cause rain.

The water cycle is one of the best and easiest way to understand rain. Because it all starts in the evaporation process to condensation and precipitation. To be more specific evaporation is the process whereby the sun shines on ocean, river, dams when the sun reflects evaporation is formed. When its formed it rises because it has turned into a gas phase which is warm and warm air rises, then when it has risen it will condense in the sky and form new clouds and when condensed they will then precipitate once they are big enough they will act as rain. In specifying the whole cycle it goes from gas solid liquid.

Well I used to believe to believe that rain was natural don't get me wrong it is but now I also believe in the water cycle.

What I want to ask you is what the latest release as far as B.M.W vehicles are concerned.

Appendix N

United States Advanced Class Instructor E-mail Guidelines for Electronic Artifact

Reply Reply to all Forward Help

From: UMSL, nascep_3 Sent: Tue 12/7/2004 12:08 PM
To: MY LEARNERS
Cc:

Subject: Week 11
Attachments:

WHAT'S UP TODAY?

Hi everyone,

Attendance
Answer my e-mail and I will send you a reply.
Please tell me:

1. *How would you describe yourself?*
2. *To what groups do you belong?*
3. *If you say rain comes from the water cycle and God, do you think they can both happen together?*
4. *Do you think there is one way to explain things in nature like rain or how the leaves on trees change color in the fall or do you think there is more than one way or more than one reason things in nature happen?*
5. *Why do you think we study science?*
6. *What do you think are the 2 most important things about you that your South African cohort should know that they may not know or may have the wrong idea about?*
7. *Have you learned anything about your cohort that you did not know before? Is there anything you have changed your mind about regarding the schools, learners or life in South Africa?*

Insert your photo into your letter for your cohort.
E-mail your letter as an attachment to me at nascep_3@umsl.edu
Save it to Marley!
Begin a Zulu dictionary word table document.
Save it to Marley!
Share something interesting with us about South Africa and KwaZulu-Natal province.
Save it to Marley!

R-E-S-P-E-C-T It means all the world to me!

Always go well,
Ms. Kathleen

United States Advanced Class Learner Artifact Addressing Instructor E-mail Guidelines

Reply Reply to all Forward Help

From: Serwa Sent: Tue 12/7/2004 4:59 PM
To: UMSL, nascep_3
Cc:

Subject: all about me
Attachments:

View As Web Page

My name is serwa and I am 5"3.i am 12years old. I have brown eyes; I have long black and brown locks down my back, I have small lips, I medium size fingernails. I am African-American, and I am kind of independent because I really don't like doing things with people because I focus more by myself because there's no distraction or disagreements. I would say that the water cycle and god happen together but god does most of the work because he is what made it and he controls it and water cycle is just the title of his works. I think the one word you can say for nature and how it works is god because he is the one made it and so I really don't what to say other than that. I think we study science because we need to learn more about are environme! nt because everything you see that is surrounded by you has science in and may be if you know about more about your environment and realize how important it is to you, you would have more respect for it and not destroying it by polluting it and littering it. I my cohort should know that I don't act any different than they do and that I don't think I am better than them. I have learned that they have to wear uniforms.
