Advances in Social Sciences Research Journal – Vol.4, No.24
Publication Date: Dec. 25, 2017
DoI:10.14738/assrj.424.3903.

Semali, L. M. (2017). Rethinking the Existentialist 'Crisis of Interest' in School Science through Culturally Responsive African Curriculum of STEM Science. *Advances in Social Sciences Research Journal, (424)* 57-64.

Rethinking the Existentialist 'Crisis of Interest' in School Science through Culturally Responsive African Curriculum of STEM Science

Ladislaus M. Semali
Penn State University

ABSTRACT

Many secondary teacher educators are challenged by failure to rekindle interest in science content with future teachers who often express a lifetime of negative associations with school science. This study involved science teachers in a participatory action research project to investigate the fear of STEM science as a field of study for African students. One way to enhance interest is through informal science experiences immersed in teaching through integration (e.g., of mobile technologies or immersing students in the natural environment). Findings of the study revealed that science education is desperately in need of reform. Teachers observed that science subjects continue to be taught using traditional means of "chalk and talk." They noted that failure to resolve this crisis is likely to contribute to learners' disenchantment with school science, drop- out from school or likely engender students' bearing long-term disinterest in formal science education. This fear originated from a long-standing myth that science is a hard subject, a misconception that must be overcome by any means necessary.

Research and publication of this study were partially funded by a grant from the africana research center at the pennsylvania state university

INTRODUCTION

What is the existentialist *crisis of 'Interest'* in School Science? The present study examined the challenges many teacher-education colleges and universities in Africa face by failure to *rekindle interest* in science content with future teachers who often express a lifetime of negative associations with school science. This report presents the findings (in three papers) of a study of science teachers in Tanzania that address: (1) crisis of interest in STEM school science, (2) Integration of cultural knowledge in STEM classes and (3) a Framework of culturally responsive African STEM science curriculum. This article addresses the first part on the crisis of interest.

The study involved science teachers in a participatory action research project to investigate the fear of STEM science as a field of study for African students. For example, the study of physics, chemistry, and biology (PCB) by African students is fraught with many challenges, failure and fear of science as "hard subjects" (Semali & Mehta, 2012). This fear has origins from a long-standing myth that science is a hard subject. Students in general and women in particular are pre-warned and told that when choosing an area of study, should avoid STEM subjects all together. This myth is entrenched among students, teachers, and parents and it is, in part, the origin of the negativity reflected in the existentialist '*crisis of interest*' in science education. Often, prospective teachers enter teacher education programs with negative views of their ability in science.

Purpose of the study

First, the researcher designed the study to involve science teachers to examine African historical reports and the history of science from which science teachers could discover the basis of the *fear of science.* The goal was to scrutinize the linkages between students’ experiences in Indigenous communities, garnered from their localized knowledge, natural environments and real-life experiences, as juxtaposed with students’ dispositions toward school science education as taught in African classrooms. This participatory study pressed teachers to search for the basis of the fear of science among their students. Focus groups examined the concept of indigenous innovations in its relationship to learning STEM education in science subject-content that teachers taught in Tanzania’s secondary schools. Interviews and open discussions formed the data sources explored to determine the locus of control in STEM education. Teachers examined textbooks, classroom teaching practices, teachers’ beliefs and schemes of work for teaching and learning physics, chemistry and biology. The goal was to confront the existing *fear of STEM science* as a field of study for African students. (See Figure 1). Second, the study aimed to observe teachers in science classrooms and model for them ways in which to integrate and teach culturally responsive science subjects. The goal was to evaluate the methods used to teach science practicals embedded in the iSPACES model of integrating STEM curriculum with Indigenous innovations. The model of locally developed practicals that aspires to solve community problems stands for Innovation, Science, Practicals, Application, Conceptualization, Entrepreneurship, and Systems. This model of teaching science emphasizes the teaching of practical skills to develop scientific expertise, and employs a pedagogy that involves participatory teaching and learning techniques that value innovation, and critical exploration with an entrepreneurial focus.

Figure 1: Engaging students in practical science

Theoretical Perspectives

Debates on the nature of science and science learning informed the present study as reflected in the body of literature that analyzes tensions between disparate perspectives on science education (Aikenhead, 1999; Boyce, Mishra, Halverson, & Thomas, 2004). Emphasis on the focus of this practical curriculum exploited the “*wow-effect*” in science teacher education (Kamstrupp, 2016). The *wow-effect* and the quest to solve problems are a phenomenon in science teacher education enacted in a particular way of teaching that “wows” students by stimulating their imagination to find explanations for why things are or behave in certain ways. In part, it is a recognition that we become bored or lose *interest* in our postmodern, consumerist Western-dominated world and that fear and boredom are related to this existence and hidden within it (Mansikka, 2009).

Proponents of this *wow-effect* rationale believe that informal environments provide students with unique experiences that allow them to participate actively in school activities while promoting a positive attitude and increased *interest* in science (Boyce, et al., 2004). One way to enhance interest is through *informal science* experiences immersed in teaching through integration (e.g., of mobile technologies or immersing students in the natural environment). The specifics of this holistic methodology for teaching science require discussion of restructuring existing science curricula and rethinking the pedagogy of physics, chemistry and biology (PCB) to overcome students' cognitive conflicts between everyday life and academic science (See, Semali, Owiny & Hristova, 2016; Semali, 2013).

Therefore, science educators must recognize that students' interactions and experiences with the natural world shape their ideas in significant ways. Often science teachers exacerbate the situation by viewing each student as *tabula rasa* to fill with principles and theories or they presume perfect prior knowledge within which to build more-complex concepts. The possibility of students' intuitive ideas about natural phenomena is rarely acknowledged. In turn, teachers must realize that children "don't just passively receive information," but instead "operate on it and transform it," based on global and personal experiences (Baker & Piburn, 1997, p. 31). In this instance, the integration of informal knowledge from the natural world of students is particularly useful in engaging underrepresented students in learning science and dispelling the myth that science is a "hard" subject.

As an interdisciplinary approach, the *i*SPACES model was introduced in some schools as an alternative way of teaching science that was informed by a variety of theoretical and epistemological perspectives represented in the acronym that bare the label of the disciplines of Engineering, Education, and the Sciences. However, the overarching concept is framed on the basis that every indigenous culture has an orientation to *learning* that is metaphorically represented in its art forms, its way of life consistent with the community, its history and language, and its way of understanding itself in relation to the community's natural environment.

The ultimate goal of this project was to prove whether the claims could stand. First, whether using traditional knowledge in science lessons, activities, and class projects gives added depth, interest, and meaning to difficult concepts. Second, whether the claim that Indigenous knowledge builds communication and respect with the community. Third, whether science education content taught in conjunction with local traditional knowledge brings a sense of place and helps to make science less alien to students. However, we must take note of the tacit assumption that there may be a mismatch between cultural perspectives that results in young Africans and other Indigenous students becoming alienated from science. The newly introduced *i*SPACES experimental curricular framework attempts to bridge this gap by honing on integrating indigenous innovations, traditional values and history, teaching principles, and concepts of nature with those of STEM school science.

Methods, techniques, or modes of inquiry

The Participatory Action Research (PAR) process of building a culturally responsive science curriculum in *i*SPACES focused on improving the quality of teaching by means of a self-reflecting process to explore and solve problems (Whyte, 1991). The arguments supporting PAR are many. These claims include the notion that educational policies and practices based on research with intended beneficiaries of school science are more likely to meet the interests and needs of students and teachers, and that those educational reforms or interventions based on cultural knowledge and experience are more likely to be relevant, "home grown" and therefore sustainable (Kothari, 2004). Teachers explored these innovative ways in the *i*SPACES framework with open minds through an informal environmental science experiment that aimed to engage African ninth-grade students (Form 1 students in Tanzania) in an informal learning environment supplemented with cameras. The basic structure of PAR followed in this study was an ever increasing spiral process of planning, acting, observing, reflecting, developing theory and re-planning model of engaging participants in a project-based research cycle of diagnose, prescribe, implement, and evaluate was applied to this project to enable teachers to stay focused (McTaggart, 1997, p. 34; Stoecker, 2005).

Data sources, evidence, objects, or materials

Data gathering was operationalized in several formats including a survey questionnaire, interviews, classroom observations, and focus group discussions. Documentation of minutes of systematic face-to-face meetings of science teachers were collected and included in the field data as part of the overall data collection matrix. Meetings and focus group interviews were conducted in English and the notes were circulated back to the groups for verification. Basic interviewing techniques were used to facilitate mutual participation and reflection. The themes of the questions were: (1) how science teachers engage students, staff, and administrators to value culturally responsive STEM curriculum. (2) How can science teachers achieve the goal of designing, teaching, and practice a culturally responsive African STEM science curriculum? (3) What is the place of local or Indigenous innovations in a STEM curriculum framework?

RESULTS

This study generated lots of discussions and field notes, observation data and interview data. Preliminary results summarize impressions and teachers' understanding of culturally responsive STEM curriculum. Partial analysis of the massive data paint a grim picture of science education that is desperately in need of reform. Teachers recognized that science continues to be taught using traditional means of "chalk and talk. See Figure 2.

Figure 2: Rote learning, chalk and talk is the main method of delivery of content

The rigid science curriculum syllabi are nationally distributed. The examples, methods, and practicals contained in these syllabi prompted instructors to transmit content according to a prescribed timetable and guided by pedagogy of "teaching to the test" through rote or memorization-based instead of developing practical skills. Few teachers find time to venture outside the classroom to explore the natural environment. Large classes made it difficult for students to perform experiments. Classroom observations confirmed that most of the students learned through rote and teaching and learning were pursued theoretically without doing practicals. See Figure 3.

Figure 3: Science classroom

Motivation to pursue science teaching as a career was low. The perception was that those who taught science subjects were not compensated fairly relative to the effort and time they put into preparing for science classes, experiments and labs.

DISCUSSION

This study is work in progress and it seems there is much to be learned from this study when the analysis of all the data is completed. Even though the use of PAR does not provide a silver bullet to educational reform, we learned that consensus was high among participating teachers.

First, we concur with Leu and Price-Rom (2006) that a good basic education is the result of the interaction of multiple actors—administrators, students, community and teachers. It is essential that the teachers become sufficiently knowledgeable about the subject matter of STEM subjects and successfully having completed a minimum of secondary education or bachelor's degree to be able to implement effective pedagogical methods that value local knowledge systems and best practices in teaching (Rogan & Grayson, 2003). Findings showed that what is critical in physics education, for example, is that the nature of commonsense knowledge, which is the initial patrimony of learners, is quite different from scientific knowledge: it is context-dependent, focusing on contradictions rooted in personal experience, and therefore resistant to change; and generally expressed in natural language. For example, students were not challenged to explore physics of mechanical innovations in the local community. See Figure 4.

Figure 4: Local women in the village demonstrate how they extract juices from sugar cane using local technologies and indigenous ingenuity.

Second, research facilitators in this study strived to bring out the best insights from all participants; however, this was not without challenges. Constantly, there was tension between human agency and scientific determinism. That is, human agency cannot bring about changes to the environment since everything in it is predetermined. Since every event in nature has a cause or causes that account for its occurrence, and since human beings exist in nature, human acts and choices are as determined as anything else is in the world. Simply put—the tension emanates from determinism on the fact that our scientific laws are deterministic since they emphasize the scientific doctrine that all occurrences in nature take place in accordance with natural laws. The theory holds that all or most of a man's life is determined for him by factors beyond his control, be they the environment, heredity, or a host of other external forces that play upon him. The concept of free will, when it is considered at all, is relegated to an insignificant place in the make-up of the human person (Müller, & Placek, 2016).

Third, the principles of PAR such as mutual collaboration, reciprocal respect, co-learning and acting on results from the inquiry are essential in student-faculty and faculty-administration relationships. Self-awareness, the ability to self-critique and reflect in a deep manner are gears essential for the development of a science program where the stakes are high. Teachers observed in focus group meetings that some common learning obstacles encountered by learners when studying physics are related to naïve ideas and reasoning patterns coming from common-sense knowledge and conflicting with disciplinary knowledge. As a simple example, we may quote the difficulties created by the different meaning that some terms such as force, energy, temperature, heat, field, ray, wave, etc., have in everyday language with respect to their definitions and formulas in physics. However, commonsense knowledge should not be considered as something negative or undesirable. In fact, common sense directly derives from the daily interactions with the natural environment and considered appropriate and even necessary for everyday life. Through focus group meetings, teachers produced principles to guide a culturally responsive African STEM science curriculum that outlined (a) the characteristics, (b) the strengths and (c) the challenges. Appendix A summarized teachers' understanding of the crisis of interest and the principles necessary for addressing the crisis.

Fourth, the issues of power and its analysis in science reform particularly in understanding the everyday nature of social control are critical and as it was shown, these issues came to a head early on in the present study. Therefore, although participatory approaches to curriculum development attempt to reveal subjugated knowledges, those that have been hitherto disqualified as insufficient or insignificant, there remains in the practice of participation forms of control and dominance. Such practices are not articulated in the direct and immediate relationship between participant and observer. They are constructed historically through all sorts of social practices, customs, and rituals.

References

Aikenhead, G. S., (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269–287.

Baker, D. R., & Piburn, M. D. (1997). *Constructing science in middle and secondary school classrooms.* Boston: Allyn and Bacon.

Boyce, C. J., Mishra, C., Halverson, K., & Thomas, A. K. (2004). Getting students outside: Using technology as a way to stimulate engagement. *Journal of Science Educational Technology 23*, 815–826.

Boyce, C. J., Mishra, C., Halverson, K., & Thomas, A. K. (2004). Getting students outside: Using technology as a way to stimulate engagement. *Journal of Science Educational Technology 23*, 815–826.

Kamstrupp, A. K. (2016). The wow-effect in science teacher education. *Cultural Studies of Science Education 11*(4), 879–897.

Kothari, U. (2004). Power, knowledge and social control in participatory development. In Cooke, B. & Kothari, U. (eds.) *Participation: The new tyranny?* London: Zed Books, 139-152.

Leu, E. & Price-Rom, A. (2006). Quality education and teacher learning: A review of literature. Washington, DC: USAID Educational Quality Improvement Project 1.

Mansikka, J. E. (2009). Can boredom educate us? Tracing a mood in Heidegger's fundamental ontology from an educational point of view. *Studies in Philosophy and Education, 28*(3), 255-268.

McTaggart, R. (1997). Participatory action research: International contexts and consequences. New York: SUNY Press.

Müller, T., & Placek, T. (2016). Defining determinism. *The British Journal for the Philosophy of Science,* axv049.

Rogan, J. & Grayson, D. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25*(10), 1171-1204.

Semali, L. (2014). The iSPACES framework for rethinking a culturally responsive secondary science curriculum in Tanzania. *Journal of Contemporary Issues in Education*, *8*(2): 32-46.

Semali, L. (2013). The *i*SPACES Framework for Rethinking a Culturally Responsive Secondary Science Curriculum in Tanzania. *Journal of Contemporary Issues in Education, 8*(2): *32—46.*

Semali, L. & Mehta, K. (2012). Science education in Tanzania: Challenges and policy responses. International *Journal of Educational Research 53*, 225–239.

Semali, L. M., Hristova, A., & Owiny, S. A. (2015). Integrating Ubunifu, informal science, and community innovations in science classrooms in East Africa. *Cultural Studies of Science Education*, *10*(4), 865-889

Stoecker, R. (2005). Research methods for community change: A project based approach. Thousand Oaks, CA: Sage.

Whyte, W. F. (1991). *Participatory Action Research.* Newbury Park: Sage.

APPENDIX A

*i*SPACES—Culturally Responsive African STEM Science Curriculum

STEM: Science, Technology, Engineering, and Mathematics

African responsive science curriculum attempts to bridge the dichotomy between home and school; and integrate Indigenous science with STEM science around topics with aims to enhance the cultural wellbeing, the science skills and knowledge of African students. It assumes that students come from rural communities to school not as *tabula rasa* but with a whole set of traditional beliefs, languages, skills, metaphors, stories about science, and understandings, formed from their experiences in the homes or community in which students matured. The role of school STEM science is not to ignore or replace prior—Indigenous—understandings, but to recognize and make connections to that understanding. It assumes that there are multiple ways of learning, knowing, viewing, structuring, and transmitting knowledge about the natural world—each with its own insights and limitations. It thus values both the rich knowledge of African cultures and of STEM science, and regards *Indigenous science* as complementary to STEM science in mutually beneficial ways.[1]

What are the characteristics of culturally responsive STEM science curricula?

- It begins with topics of cultural significance and involves local experts, entrepreneurs, local historians, and healers.
- It links instruction on the fundamentals of STEM with locally identified topics, stories, artifacts, history, weather, and discoveries.
- It devotes substantial blocks of time, provides many opportunities for students to develop a deeper understanding of African Indigenous knowledge linked to STEM pedagogical knowledge, improves students' problem solving, and critical analysis skills.
- It incorporates teaching practices, examples that are both compatible with the African cultural context, focus on students' understanding, use of STEM pedagogical knowledge, and skills in the African environment to solve problems.
- It engages in STEM-content-knowledge *ongoing assessment,* which subtly guides instruction, taps deeper cultural and scientific understanding, reasoning, and skill development tied to established known pedagogical standards.

What are some positive strengths of culturally responsive STEM science curriculum?

- It recognizes the value, validates what children currently know, and builds upon that cultural knowledge toward disciplinary and sophisticated understanding of scientific constructs from both STEM and Indigenous science perspectives.
- It taps the often-unrecognized expertise of local people and links their contemporary observations to a vast historical database gained from living on the land, in the community, and in society.
- It provides for rich inquiry into different knowledge systems and fosters collaboration, mutual understanding, and respect for cultural knowledge.
- It creates a strong connection between what students' experience in school and their lives out of school. It addresses the fundamentals of STEM education content from multiple worldviews.

What are some challenges associated with culturally responsive STEM science curriculum?

- Cultural knowledge may not be readily available or easily understood by science teachers.
- Cultural experts may be unfamiliar, uncomfortable, or hesitant to work within the school setting.
- Current core science textbooks (physics, chemistry and biology) may be of little assistance in generating culturally relevant activities; most nations' textbooks and policies, which should inform teachers on what content to teach and how to teach it, are not readily available.
- Curriculum developers, universities, and school supervisors or school administrators (head teacher, subject area coordinators) support for planning, design and implementation of integrated cross-disciplinary, and integrated STEM curriculum, *may be lacking*.
- To develop a *culturally sensitive curriculum* takes time, passion, and commitment.

Project partially funded by a grant from the Africana Research Center at The Pennsylvania State University. For more information, contact, L. Semali, lms11@psu.edu

---

[1] Adapted from the Alaska Native Knowledge Network. See, Semali (2014):