Exploring the Interaction with Indigenous Craftsmen on Senior Secondary School Students' Achievement in Physics

Subject/Problem

A major problem confronting physics education in recent times is the steady decline in students' enrollment in physics at both high school and university (Semela, 2010; Osborne, Simon & Colins, 2003; Orji, 2000; Australia Council of Deans of Sciences, 2007; Ho & Boo, 2007). Even though physics is fundamental to all sciences, recognized as the foundation of our society (Pravica, 2005), and is believed to play an indispensable role in economic development (Stocking, 2000; the Institute of Physics, 2003; National Research Council, 2001) it is surprising that research has continued to report that most students hold erroneous ideas about physics, and perceive it as being all about formulae, too boring, confusing and difficult (Noel, 2006). And even though students are immersed in daily events and activities related to physics and most of its concepts, and experience the application of physics (examples: moving objects such as cars, energy and use of screwdrivers, knives, bottle-openers) in their daily lives yet there appears to be a disconnect between student's everyday life and what happens in their academic classrooms. For example many students use products of physics such as knives, screwdrivers, fans, can openers etc. (Anderson, D; Kisiel, J; & Storksdieck 2006) but when confronted with academic questions about the physics principles that underlie the functioning of these products, they are unable to answer them using physics principles. It therefore follows that there is a disconnect between teaching and learning that goes on in schools and students' home and their day to day activities in their communities. "Schools are in communities but often not of communities" (Bouillion, and Gomez, 2001, 878). Schools fail to point students to the application of physics in their real world contexts and are probably responsible for the reported lack of interest, motivation and poor achievement in physics (Reiss, 2009; Sjoberg, 2001; OECD, 2005; Noel, 2006).

Perhaps the forgoing problem may be attributed to the inappropriate conventional methods of physics instruction (Omole 2010) that tend to "emphasize compartmentalized knowledge often decontextualized and taught in the detached setting of a classroom or laboratory" (Barnhardt, 2005, p. 11). Conventional educational culture especially in Africa does not take into account the place of indigenous culture and the interrelatedness that exist between school based practices (Curriculum, and instructional strategies) and the students' social, cultural and environmental contexts (Kawagley et al. 1998). Indigenous people have traditionally acquired their knowledge through direct experience in the natural world. For them, information is understood in relation with the context of everyday survival. This serves to corroborate other reports (Anderson, Kisiel & Storksdieck, 2006; Anderson, Lucas, & Ginns, 2003) that indicate that learning in out-of-school contexts have often helped students to construct valid physics knowledge, by providing students with personal experiences that allow them to interact with the world around them without the constraints of the classroom environment.

This type of curriculum, which emphasizes experiential, outdoor learning in familiar traditional environment, has been reported to improve science learning (Aikenhead, 2001a; Murray, 1997; Riggs & Semken, 2001). This form of science education allows students to learn more about the natural world in which they live than they do sitting in the classroom and taking notes. It goes beyond the conventional model of instruction commonly found in most classrooms to the more dynamic interdisciplinary approach that engage students in critical inquiry of collecting, analyzing, and synthesizing data in order to solve problems of their environment and create knowledge and innovations of their own.

Acclaiming the benefits of situating science instruction within student's everyday context, the U.S. NRC in its consensus report, Learning science in informal environments: People, places and pursuits (Bell, Lewenstein, Shouse, & Feder, 2009) acknowledged the abundant evidence that support the notion that informal/free-choice science learning efforts and everyday experiences contribute to student's engagement, understanding and interest in science. This report considers learning as life-long, life-wide and life-deep enterprise and therefore justifies the current research focus on learning science in out-of school environments. Keeping students interested in the sciences particularly physics is important for the continuity of scientific endeavor and also to ensure scientific literacy of future generations (Trumper, 2006). In line with previous efforts to situate science within students' out-of-school local environment, the current study explored the questions:

- What impacts do students' interactions with local indigenous craftsmen have on their Physics achievement?
- Are there marked differences in students' achievement between students who had the opportunity to interact with local indigenous craftsmen and those who did not?
- What are the differences in students' achievement in Physics between girls and boys who interacted with local indigenous craftsmen?
- How did students perceive the opportunity of interacting with local indigenous craftsmen?

Three research hypotheses set guided the analysis of the research.

1. There is no significant difference in the physics achievement between the SSSII students who interacted with local craftsmen and those who did not.
2. There is no significant effect of physics students' interaction with local craftsmen on their achievement.
3. There is no significant effect on students' achievement in physics of the gender of the physics students as they interacted with the local craftsmen.

Theoretical Framework

Emergent studies are increasingly coming to a consensus on the notion that students' cultural background and practices play a critical role in the ways they participate in the classroom as well as their learning and achievement (Aikenhead & Ogawa, 2007; Brown, 2004; Rodriguez, 2001; Tobin, 2006). Contrary to the general conception that students learn better in a formal classroom setting studies are replete that demonstrate the benefits of holistic and cross-contextual learning. The current study is therefore framed around the beliefs that effective science teaching and learning should be participatory, place-based and a combination of in-school and out-of-school contexts. This is based on the premise that science education is most effective when situated within students' natural environment using the most natural method that helps students to explore their surroundings and to understand life. Literature (Anderson, Kisiel & Storksdieck, 2006; Anderson, Lucas, & Ginns, 2003) has laid credence to the benefits of teaching in out-of-school contexts and provide evidence to support the notion that this type of teaching is effective in helping students construct valid physics knowledge. A plethora of such studies (Baker-Graham, 1994; Eaton, 2000; Manzanal et al, 1999; Bogner, 1999; Salmi, 2003) indicate that out door learning experiences are more effective in developing cognitive skills than classroom-based learning (Baker-Graham, 1994; and Eaton, 2000). Rickinson, Dillion, Teamey, Morris, Choi, Sanders & Benefeild (2004) defined the concept of outdoor learning to include any range of educational activities in any settings outside the classroom such as outdoor adventure education, field studies, nature studies, outdoor play, heritage education, environmental education, experiential education and a visit to farm. This kind of science education provides students the opportunity to contextualize what they are learning (Zoldosova & Prokop, 2006) in a way that promotes meaningful learning. The current study is premised on the belief that the most natural learning is achieved through personal experience as individuals interact with the world around them, acquires new information without the constraints of the classroom environment.

Design or Procedure

A mixed-methods approach to data collection and analysis was used for this study. The use of qualitative method to complement the weaknesses of a single method quantitative to deemed appropriate to increase the validity of the study. The quantitative part of the study employed a quasi-experimental non-randomized pre-test, post-test, non-equivalent control group design. Randomization was not possible because school authorities showed reluctance to use a large proportion of the school in the study. Hence, intact classes were used.

The qualitative data was collected using a semi-structured interview (for students and teachers) and classroom and workshop observation. Study sample consisted of one hundred and seventy-eight students (88 from two experimental schools and 90 from the control schools) selected from four intact co-educational senior secondary school physics classes. Students from the experimental schools and their and three teachers were interviewed in order to obtain their views on the phenomenon being investigated. Interview was used because it gave the respondents freedom to express their views in their own words and provide reliable, comparable qualitative data (Cohen & Crabtree, 2006). Observation was used to capture the rich interactions that went on between students and the local indigenous craftsmen at the workshop sites and those that went on between the teacher and students during classroom instruction prior and after the visit to the mechanic workshop.

Instrumentation for Data Collection

Four Instruments: Physics Achievement multiple-choice Test (PAT), Machines Observation Schedule Protocol (MOSP), Student Interview Schedule (SIS) and Teacher Interview Schedule (TIS) were used to collect data for this study. Senior Secondary School II (SSS II) students' physics achievement data about machines (a first term physics content from the National and State curricula) was collected using the PAT, which had a reliability coefficient of 0.75 and whose face validity was determined by three experienced university physics educators and two seasoned Senior Secondary teachers.

Analyses and Findings

Quantitative data was analyzed using both parametric and non-parametric statistics using the Statistical Package for Social Sciences (SPSS). While means, standard deviations, and Pearson's correlations were used to answer the research questions, the data for the null hypotheses, were subjected to descriptive and ANCOVA statistical techniques. The qualitative data analysis was done through the thematic approach code and organize teacher and students' responses to the structured interview and some of these data were transcribed verbatim using the narrative technique. The structured interviews of both teachers and students were used to compliment field notes from observations.

Result

Table 1 shows the means and standard deviations of the test scores of students before and after they interacted with the local craftsmen who used local indigenous technological tools in their workshops and served to answer the research question: *Are there marked differences in students' achievement between students who had the opportunity to interact with local indigenous craftsmen and those who did not?*

Table 1: Mean and standard deviation of student test scores.

Category	N	Mean	S.D	Gain score
Pretest scores of student who did not interact local craftsmen	76	8.56	1.96	
Posttest scores of students who did not interact with local craftsmen	76	13.38	2.85	4.82
Pretest scores of students who interacted with local craftsmen	76	8.00	1.52	
Posttest scores of students who interacted with local craftsmen	76	15.54	3.07	7.54

Table 2: Pairwise comparisons of students' posttest scores

Category	N	Mean	Mean differences	p. value
Posttest scores of students who did not interact with local craftsmen	76	13.38		0.000
Posttest scores of students who interacted with local craftsmen	76	15.54	2.151	

Table 1 shows that both the experimental and control groups had reasonable gain scores from the pre-test to the posttest with gain scores of 7.54 for the experimental group and 4.82 for the control. Further in depth analysis through a pairwise comparison of the posttest scores of the experimental and control groups reveal a significant mean difference of 2.151 in favor of the experimental group (See Table 2) in their posttest scores. This nullifies the hypothesis of no significant differences between the experimental and control and also confirms significant effects on students' achievement of their interaction with the indigenous craftsmen.

To further verify the impact of students' interaction with local craftsmen on their physics achievement, an analysis of covariance was conducted on the students' test scores, the result (Table 3: not included due to constraints of space) shows that the effects of students interaction with the local craftsmen was significant {$F(1, 151) = 19.464$}. The R Squared is equal to 0.118 an indication that the interaction of the students with local craftsmen must have contributed 11.80 % of changes in students' physics achievement. The effects of the students' pretest (the covariate) was however not significant {$F(1, 151) = 0.010$}.

Table 4: Mean and standard deviation of posttest scores of male and female students.

Category	N	Mean	S.D	Mean differences	p. value
Posttest scores of male students who interacted with local craftsmen	31	15.03	2.14	0.82	0.234
Posttest scores of female students who interacted with local craftsmen	45	15.89	3.56		

When the means and standard deviations of male and female students who interacted with local indigenous craftsmen were compared it was found that there exists a difference of 0.82 in the mean achievement of male and female students, however, the difference is not significant (p=0.234). This is an indication that the atmosphere in the craftsmen workshop is not gender biased. Again, this provided an answer to the research question: what are the differences in students' achievement in Physics between girls and boys who interacted with local indigenous craftsmen? and confirmed the null hypothesis: there is no significant effect on students' achievement in physics of the gender of the physics students as they interacted with the local indigenous craftsmen.

The observation field notes, and results of the semi-structured interviews of both students and teachers during and after the visit to the local mechanic workshop corroborated the above quantitative results. Generally, experimental group students expressed excitement to have visited the local workshop and reported that they had the opportunity to ask the craftsmen questions and this helped them "learn a lot about machines". In agreement, the experimental group teachers expressed satisfaction with the whole process and reported that they will begin to use this method in teaching other physics concepts.

Conclusion and Contribution to Teaching and Learning of Science

The purpose of this study was to explore the impacts on SSSII students' achievement of their visit to and interaction with local indigenous craftsmen. Results show that generally, the physics achievement of students who participated in the visit and interacted with the local indigenous craftsmen improved significantly and that these students were very satisfied with the whole process. Analysis of the interview and observation data showed that students engaged in this visit and interacted with the craftsmen were very excited about being able to watch the craftsmen demonstrate, explain and ask questions about the workings of the different machines in their workshops. Additionally, they expressed desire for their teachers to continue with this method of instruction that tied real life application to the physics concepts they do in the classroom. Not only was students pleased with the process, the teachers marveled at the way students engaged in the discussions during and after the visit. Even though the teacher still struggled with allowing students the opportunity to ask and answer their own question, they expressed their delight in the level of participation that the visit to the workshop engendered in their students.

The current study served to corroborate previous studies in science education that suggest that engaging students in out-of school activities is effective in improving students science achievement (Anderson, Kisiel & Storksdieck, 2006; Anderson, Lucas,& Ginns, 2003), helping them construct valid physics knowledge, and developing more cognitive skills than classroom-based learning (Eaton, 2000; Bogner, 1999; Salmi, 2003; Baker-Graham, 1994; and Eaton, 2000). The fact that both teachers and students showed a great desire to continue to engage in this kind of practice clearly is a welcome development that not only promises to ameliorate the problem of low enrolment into physics classes but also holds a great future for the improvement of physics achievement specifically and science education in general. It is very gratifying to report that this study has provided a confirmation to study Kawagley et al. (1998) that emphasized the positive rewards of situating science learning within students' social, cultural and environmental contexts. Perhaps, this study will provide an added voice to previous studies that have not only suggested the integration of indigenous African culture into science instruction but also report that explicit involvement and cooperation with indigenous community members will serve to improve science learning especially in indigenous Africa (Aikenhead, 2001a; Murray, 1997; Riggs & Semken, 2001). It has added insight into the way forward in promoting context based science education in Africa and contributed to the body of knowledge on teaching, learning and research in science education in general. The long term implication of the current study for science education community is that there should be more studies on place based out-of school science education to explore the deeper dimensions of this instructional strategy and how it can be used in addressing the problems that are currently infesting science education in general and physics education in particular.

Contribution to General Interest of NARST Members

This study hold future for NARST members interested in pursuing research in informal out-of school science education as well as promises to be of interest to both NARST community and science education community as it adds credence to the literature on informal science education.

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