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SCIENCE TEACHERS' CULTURAL BELIEFS AND CONCEPTIONS OF THE NATURE OF SCIENCE AND INSTRUCTION

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Abstract

This paper summarizes findings of a study which explored the relationship between science teachers' orientation to traditional culture and their conceptions of the nature of science, science-technology related societal issues, and instructional ideology. It summarizes also their perceptions concerning interaction of traditional culture and science education. Practically the entire sample believed that indigenous culture and western science are two independent and seemingly irreconcilable systems of thinking, experiencing, and explaining phenomena. Teachers' orientation toward indigenous traditional culture was low but positively correlated to preference for traditional instructional ideology and modestly negatively correlated to inquiry instructional ideology, nature of science, and awareness of societal issue scores. They had inadequate understanding of Kimball's (1967) model of the nature of science but showed adequate conception of the Rubba-Andersen (1978) nature of scientific knowledge model. Although the teachers were pessimistic about the ability and desirability of science and technology to resolve environmental problems they had, overall, a positive and socially acceptable level of awareness of environmental conservation issues.

Background

The goal of scientific and technological literacy is now pervasive in all societies including non-western countries who are said to "have lost the freedom to exclude science as a culture from their own culture, because science and technology have become a widespread culture in the world (Ogawa, 1986; p. 117). However, as abundantly clear from predominantly western literature, scientific and technology literacy must be perceived from multiple perspectives. For example, numerous researchers identify understanding the nature of science as perhaps the most important dimension of scientific literacy (American Association for the Advancement of Science, 1989; Meichtry, 1993; Andersen, Samuel, & Harty, 1986; Lederman, 1992 & 1986; Rubba & Andersen, 1978; Kimball, 1967). Others point out understanding the interaction of science, technology, and society as another major attribute of scientific literacy relevant to the preparation for citizenship (Steiner, 1973; Yager, 1992; Volk, 1984). According to this perspective, an accurate portrayal of the nature of science requires recognizing that the progress of science and technology has social implications. Steiner (1973) argues that societal issues, like preservation and conservation of the environment, are relevant to all education but it was "especially more relevant to science education, for it is through science

and technology that many have been created, and through which help in their solution may be found" (p. 434). Another perspective on science and technology literacy is one commonly enunciated in developing countries whereby science and technology are interchanged with modernization and national development (Chisman, 1984; Cobern, 1989; Morris, 1983; Nichter, 1984).

It would appear that from these perspectives that scientific literacy can be demonstrated partially by assessing one's understanding of the nature of science and scientific knowledge as well as by assessing one's level of awareness of science-technology related issues. If, like in this study, the sample comprises of science teachers, another useful indicator of literacy is orientation to science instructional ideology. When these variables were measured, it was necessary to take into account the socio-cultural context in which the teachers operated as well as the teachers' cultural values and beliefs. Generally, the socio-cultural context molds the perceptions and expectations for science and technology in a society. As an example, Odhiambo (1968) bemoaned the tendency among Africans to appreciate the technological products of science while failing to appreciate the spirit of science and without acquiring a scientific manner of looking at nature or approaching problem situations. Other researchers have expressed surprise at the ease with which, even western educated Africans, fall back to their cultural beliefs and modes of thinking in ordinary problem situations (Morris, 1983; Yakubu, 1994; M. Bourdillon, 1987). Morris (1983) observed that African students' commitment to science was sustained only through the duration of courses of study and "once the ordeal (sic) of courses of study is over, and they can relax again, they return to the security of their earlier beliefs" (p. 23). In Nigeria a recent study of pre-degree science students showed that the indigenous world-view influences the way adult students perceive and interpret what they observe (Jegade & Okebukola, 1991). However, as Yakubu (1994) notes, these observations should not be construed to suggest that science and technology are incomprehensible to people in the developing countries, rather that spontaneous application of scientific ideas and processes in problem situations is inhibited. As he conjectures, "the inhibition is very likely to be deep-seated in indigenous cultural behavioral and thought patterns acquired before formal western education was received" (Yakubu, 1994; p. 344)

The Problem

The preceding review underscores the fact that traditional world-view is different from the scientific world view to be developed in science education. World view being the overall perspective from which one sees and interprets the world or a collection of beliefs about life and the universe held by an individual or a group (American Heritage, 1992; p. 2058) is relatively stable. Therefore, it can be assumed that due to the inevitable persistence of world-view (sometimes socially desirable) acquired in the traditional culture, science educators have to grapple with how the traditional world-view is to be integrated with the western science world-view. As science teachers are the means by which this 'traditional culture-science world-view' integration can take place, the question should be asked whether teachers have a commitment or not to indigenous cultural beliefs and values as well as how those beliefs are related to their level of scientific literacy. It is hypothesized that although they have tertiary level training in both the content and teaching of science, indigenous science teachers have orientation or commitment to some values, beliefs and thinking patterns from their culture of origin. It appears that this hypothesis is tenable. For example, both Ogawa (1986) and Ogunniyi (1988) observed that science, for many non-western students is like a second culture. It is conjectured that there are some aspects of the first culture which exposure to western science education may not change or which teachers still cling to in spite of their training. In that case, the indigenous teachers' cultural values and beliefs or world-view are expected to affect their instructional behaviors and the classroom environment they create as well as the way

they perceive and interpret the nature of the subject and phenomena. Furthermore, indigenous teachers have to deal with contradictions between their own world-view and the scientific world-view as well as between the scientific world-view and their students' world-view. For these and other reasons, there is need for deliberate efforts which seek to integrate the indigenous thought and belief patterns with the scientific world-view (Yakubu, 1994). In this regard, it was thought that a useful starting point may be determining knowledge and beliefs teachers presently have concerning science and their cultural world-view. This study was designed to address this concern; in particular it addressed the questions:

- 1) To what extent were indigenous science teachers oriented towards traditional culture?
- 2) How is their orientation to indigenous culture related to measures of scientific literacy?

Methodology and Sample

This descriptive correlational study utilized techniques that included the closed item (n = 63) and open-ended response questionnaire survey (n = 58) (Borg & Gall, 1989; Ary, et al., 1990) and a random sample focus group interview (n = 14) (Krueger, 1988) to collect data. Open response text and the interview transcript were content analyzed following the guidelines suggested by Tesch (1990).

The sample consisted of 63 science teachers enrolled in Part II of the Bachelor of Education (BEd) degree program at the University of Zimbabwe. They came from all 9 educational administrative regions but only 9 teachers on the program were female. The distribution according to specialization was biology (28.6%), physics (41.3%), and chemistry (30.0%). Their self reports on socio-cultural backgrounds showed that more than 71% grew up in a religious environment in which both Christianity and traditional religions were practiced; currently 43% practiced both Christianity and traditional religions, 41% practiced only Christianity, and 14% claimed that they were non-religious.

Results

Response profiles on the main constructs

In designing the study it was speculated that estimating teachers' level of scientific literacy could be done by finding their conceptions of the nature of science, their awareness of a societal issue such as environmental conservation, and their science instructional ideology. Since instruction occurs within a particular socio-cultural context, it was to be expected also that their conception of the nature of science and instructional ideology would be influenced by their traditional thinking, values, and belief patterns. The study measured (a) conceptions of the nature of science, (b) environmental conservation awareness, (c) preference for science instructional ideology, and (d) orientation to traditional patterns of values and beliefs. Table 1 summarizes scores obtained on each of the measures. It also presents the results of testing the significance of difference from the appropriate neutral index for that scale. A brief description of each measure as well as the internal consist-

ency reliability of the scales are given also in Table 1. The following section gives a summary of the main findings for each construct measured.

Table 1. BEd science teachers' scores on measures of understanding of the nature of science, instructional ideology preference, and orientation to indigenous culture (N = 63)

Construct and Measures ^a	Mean total score ^b	SD	d- score	t
Orientation to indigenous culture (OICS) [42]	102.5 [2.4]	13.7	-23.5	-13.65***
Nature of science (NOSS) [29]	74.4 [2.6]	7.2	-12.6	-13.98**
Nature of scientific knowledge (NSKS) [48]	168.8 [3.5]	12.9	2 4.8	15.18***
Inquiry instructional ideology (STIPS) [10]	38.4 [3.8]	4.2	8.4	15.68***
Traditional instructional ideology (STIPS) [10]	33.6 [3.4]	4.5	3.6	6.19***
Environmental-conservation awareness (ECAS) [48]	117.2 [3.4]	10.7	12.2	9.02***

** $p < .01$

*** $p < .001$

^aNumber in the parentheses is the number of items in the scale or subscale.

^bThe numbers in parentheses are the score equivalents on the 5-point scale.

Notes: The following are the scale interpretations:

OICS = a researcher developed scale purporting to measure the degree of science teachers' orientation toward traditional culture. Significant low orientation to indigenous culture found (internal consistency reliability = .71).

NOSS = developed by Kimball (1967), adapted to a five point scale, indicates knowledge of the nature of science by agreeing to model points. Significant low and inadequate conception of the nature of science obtained (.40).

NSKS = developed by Rubba and Andersen (1978) to measure understanding of nature of scientific knowledge as creative, developmental, parsimonious, amoral, testable and unified. Significant and adequate conception found (.62).

ECAS = adapted from Steiner (1973) and Richmond (1976), indicates level of environmental-conservation awareness. Significant and socially acceptable level of awareness found (.63).

STIPS = developed by Jones and Harty (1978) measures science teachers' instructional inquiry or traditional ideologies. Significant level of preference for both inquiry and traditional non-inquiry instructional ideology found (.37).

(i) Nature of science and scientific knowledge

Perception of science teachers on the nature of science and scientific knowledge were compared to models of the nature of science (Kimball, 1967) and scientific knowledge (Rubba & Andersen, 1978) and to perceptions of teachers in other countries. The total score on the Kimball scale (mean = 74.37 SD = 7.18 $t = -13.98$ $p = .001$) showed that BEd science teachers had inadequate understanding of the nature of science. Internal replication with the Rubba and Andersen (1978) NSKS found that BEd teachers' had an adequate conception of the nature of scientific knowledge (mean score = 168.81 SD = 12.86 $t = 15.18$ $p < .0001$). Comparison of NOSS profiles to those reported in two other countries, Nigeria and the United States of America, were made using data reported in previous studies (Andersen, et al., 1986; Cobern, 1989). An ANOVA (Hinkle, et al., 1988) with total NOSS score as the dependent measure detected significant differences in the scores among the three groups ($F_{2,84} = 9.51$ $p = .0002$) with score magnitude in the order USA > Nigeria > Zimbabwe. The Spearman rank correlation coefficients of the three samples were positive ($p < .01$); .93 for Nigerian and Zimbabwean samples and .69 between either of these two groups and the USA sample. Although their actual scores were significantly different, their ranking of items in terms of relative agreement to the Kimball model are quite similar. Comparison of the nature of scientific knowledge (NSKS) profiles of Zimbabwean teachers and American high school biology teachers (Lederman, 1986) was also done. The Lederman sample scored consistently and significantly higher NSKS scores on every scale compared to the Zimbabwe sample.

(ii) Societal issues

Awareness of a societal issue, environmental conservation, was tested with data obtained using a researcher adapted four factor environmental-conservation awareness scale (ECAS). Overall, BEd science teachers had a positive and socially acceptable level of orientation to environmental-conservation issues (mean = 117.17 SD = 10.72 $t = 9.02$ $p = .0001$). They had significantly positive environmental conservation awareness scores for factors I, II, and III dealing respectively with pessimism in science and technology, conservation and preservation of the environment, and taking personal responsibility in resolving environmental issues. Their score on Factor IV, optimism in science and technology's ability to resolve environmental issues, was neutral (mean = 29.90 SD = 3.96 $t = -0.20$) indicating that teachers neither had nor lacked optimism in the ability concerning the desirability of science and technology to solve or to deal with societal problems or environmental deficiencies.

(iii) Instructional ideology

Science instructional ideology or preference was measured on the two factor Jones and Harty (1978)

science ideological preference scale (STIPS). BEd science teachers had both a preference for inquiry (mean = 38.35 SD = 4.20 $t = 15.68$ $p < .0001$) and a preference for traditional non-inquiry instructional ideology (mean = 33.63 $t = 6.19$ $p < .0001$). Their preference for inquiry ideology was significantly higher than for traditional or non-inquiry instructional strategies ($t = 5.14$ $p = .0001$). Their scores on the inquiry subscale and those on the traditional subscale had an inverse relationship ($r = -.22$ $p = .05$).

(iv) Orientation to indigenous values and beliefs

Science teachers' orientation towards traditional culture was measured using a 42-item researcher developed orientation to indigenous scale (OICS). Overall, BEd science teachers had a low orientation toward indigenous culture (mean score = 102.49 SD = 13.66 $t = -13.65$ $p .0001$). The range of OICS scores was a moderate low of 70 to a moderate high of 142 suggesting that respondents varied from those with relatively weak inclination toward indigenous culture to those with a fairly high inclination toward it. Their responses to items fitting the sex role stereotype and problem solving categories showed an orientation which would be desired in modern science education. For example, 92.06% were in agreement that "with science classes every attempt should be made to create an image of science in which scientific activity is not dominated by any one sex" suggesting that in their responses the teachers were not holding gender-biased expectations. More than 95% disagreed to the statement "pupils must accept facts as they are presented to them, expressing doubt is a sign of disrespect". Their orientation to social change was positive, non-conservative, and open to change; they perceived or expected some sought of change in traditional values and beliefs due to changing patterns of living or due to the influence of other cultures. The number of respondents disagreeing that "there is no logic in trying to change the way traditional values and beliefs are in Zimbabwe" (61.29%), "if a practice is widely known and embraced by the community, it is unnecessary to raise issues that may cause individuals to question its validity or relevance" (87.30%), and "I believe that there are teachings from other cultures which are valid if adopted or adapted to our own way of life" (90.47%) were clearly in the majority. They did value some traditional oriented aspects of family and authority structure although their views concerning causal attribution and religious belief were non-traditional.

(v) Interaction of indigenous culture with science education

A qualitative assessment of science teachers' perception on indigenous culture and its influence on indigenous students' perception and acquisition of scientific knowledge and processes was conducted. Two approaches, open responses to a written question and a structured random sample focus group interview as described by Krueger (1988), were used. Subsequent content analysis done on the open-ended response text, which was substantially reliable ($\pi(\delta) = .93$), produced the following picture. Practically all teachers' (94.83%) providing open response data mentioned or exemplified a negative interaction of indigenous culture with science education. They acknowledged that indigenous culture and science education are two systems of thought with substantially independent ways of thinking and explaining phenomena. The focus group corroborated this perception that indigenous culture based beliefs or explanations could be carried alongside, independently, or in spite of the scientific explanation. Five science teacher educators confirmed the existence of what they called "African science" referring to those aspects of reality experienced in traditional culture including witchcraft which seemed to defy scientific explanation. Fewer than 20% of the written open responses exemplified practices in indigenous culture which could be useful to science education. Overall, negative assessments were obtained for 7 categories of indigenous culture, i.e., gender bias, reverence for authority figures, religious ideology, thinking and belief associated with causality and causal attribution; top-down procedures for problem solving, con-

servative orientation to social change, and views concerning mysterious and sacred perception of relationship of humans with nature and supernatural forces.

(vi) Magnitude of relationship among constructs

The relationships among BEd science teachers' orientation towards indigenous culture and measures of scientific literacy were tested for significance by referring to tabled critical values of the Pearson product moment correlation coefficients at the .05 level for a one tailed test (Hinkle, et al., 1988; p. 659). Where pertinent a level of .01 is also reported. Based on the correlation matrix obtained the following observations were made.

Awareness of environmental-conservation was positively but non-significantly related to knowledge of the nature of scientific knowledge ($r = .20$). A positive and significant relationship ($p < .05$) was obtained between the teachers' environmental-conservation awareness scores and the instructional preference for inquiry ($r = .30$) and nature of science scores ($r = .27$). A modest negative correlation was found between the environmental-conservation scores the orientation to indigenous culture scores ($r = -.22$) and BEd Part I scores ($r = -.18$). A significant positive relationship was observed between the science teachers' orientation to indigenous culture scores and preference for traditional non-inquiry instruction scores ($r = .40$). There was lack of significant relationship between pre-service teacher training scores and between BEd Part I scores and constructs of the study. In fact, the BEd Part I score was significantly correlated to the preference for traditional ideology score ($r = .23$) and negatively to the nature of science score ($r = -.23$). The Part I score also had a modest negative relationship with nature of scientific knowledge, conservation awareness, and inquiry instructional ideology scores. Academic and professional qualification, age teaching experience, and gender as well as the socio-cultural environment variables had no substantive relationship to constructs studied. This could be due to the relative homogeneity in the sample's demographics; a homogenous sample usually tends to yield low correlations in general (Hinkle, et al., 1988).

Discussion

The study partly demonstrated that BEd science teachers' experience, observations, and perceptions concerning the interaction of indigenous culture in Zimbabwe with science education is largely negative. Their experience and belief was that indigenous experience and the basis or logic of explaining that experience was different and independent of scientific explanation. In fact, several others have also noted this problem as well as the ease with which African students fall back to their cultural beliefs and modes of thinking in many problem situations (Morris, 1983; Yakubu, 1994; M. Bourdillon, 1987; Gelfand, 1973). Yakubu (1994) notes that the spontaneous application of scientific ideas and processes in problem situations is lacking and conjectures that "the inhibition is very likely to be deep-seated in indigenous cultural behavioral and thought patterns acquired before formal western education was received" (Yakubu, 1994; p. 344).

Although they perceived the interaction of science education and the indigenous culture negatively, the science teachers acknowledged the value of science in Zimbabwe and in particular respondents in the focus group concurred that science significantly informed and improved ones' world-view and outlook. Respondents viewed science as having a positive and significant role in national development, social and health applications, technology advancement, and providing a base for producing scientific expertise. Despite this perceived value of science, the reality, according to our sample, was that scientific ways of thinking had not become a spontaneous means to view and explain experiences. They were concerned with the ease with which any experience or observation

not understood is assigned mystical qualities. A handful of respondents in this study even raised the possibility that science may be misconstrued by traditionalists as a form of witchcraft. In other comparable traditional cultural environments, science is reportedly perceived as "weird and special, requiring magical and superhuman explanations" (Jegede & Okebukola, 1992; p. 639). Overall, the results of the study underscore the conjecture that in developing countries there is need to ask "questions about world-view and the compatibility of various non-western world views with modern science" (Cobern, 1993; p. 1).

The study found that teachers' orientation to indigenous culture, although low, was positively related to a preference for traditional non-inquiry instructional ideology and very modestly negatively related to preference for inquiry ideology. The BEd program is an inservice program and enrolls relatively young teachers. Teachers in schools may be older and possibly more oriented to traditional culture. Even for this youthful sample, item analysis profiles demonstrated that teachers had some authoritarian perceptions, a tendency which was even more evident from their rating of the traditional subscale of the Jones-Harty (1978) STIPS. Therefore it is important to raise implications this authoritarian perception might have in science education since in African societies in general, there is reverence for authority figures or adults. This implies that the locus of control and authoritative knowledge lies with adults (Jegede & Okebukola, 1992) and thus authority figures are perceived as infallible sources of information and solutions to problems. For example, it is perceived as virtually inappropriate for children to query knowledge or decisions of adults. One consequence is that, the teacher being an adult figure is considered as a 'know-all' in matters relating to science education, a point well noted by researchers working in comparable socio-cultural contexts (McKinley, et al., 1992; Prophet, 1990).

Another notable point of discussion concerns the finding that BEd teachers showed both a high inquiry preference as well as traditional inquiry preference scores. This could imply that the Jones-Harty (1978) STIPS either fails to discriminate effectively between the two orientations or that teachers demonstrated a realistic assessment of classroom behavior whereby both traditional and inquiry methods are utilized and/or blended as the situation demands. The trend expected in the ideal situation where a high inquiry ideology is complimented by a very low traditional instructional preference was indicated by a significant inverse relationship between scores on the inquiry subscale and those on the traditional subscale ($r = -.22$ $p = .05$). However, given the fact that the socio-cultural context has authoritarian tendencies which may not support inquiry instruction, a comment is in order concerning the finding that teachers had a preference for inquiry instructional ideology. Although this is desirable a question remains whether this is practiced. For example, in a recent master's thesis, Tsvere (1992) surveyed physics teachers and students at Advanced level about the role and use of practical work. Over 72% of over 800 students reported that they were not given the opportunities to design their own experiments. According to Tsvere's estimate, only 28.8% of practicals stipulated in the syllabus were being done. She observes that:

... student input was minimum. Teachers did not seem to see the need for discovery experiments hence dominated the physics laboratories even at the advanced level. They dictate problems for investigation, procedures and even orders of magnitudes for the results of those investigations. (Tsvere, 1992; page not numbered in original)

Advanced level teachers have higher academic qualifications than teachers in our study and yet they too demonstrate authoritarian styles of science instruction. These observed authoritarian tendencies may possibly extend to some conceptions BEd science teachers held concerning the nature of science and scientific knowledge as measured, respectively, on the Kimball (1967) and the Rubba and Andersen (1978) models. In their responses to some items, BEd science teachers

showed an authoritarian view of scientific knowledge. For example, item analysis showed that the sample did not perceive scientific knowledge as parsimonious and that they believed in a single scientific method with a determinate number of procedural steps. They accepted the view of science as an organized body of knowledge and they did not possess a definitive understanding of the use of models and/or the role and/or the arbitrariness of definitions and classification schemes in science. Greater than 66% had an inadequate understanding of the tentativeness of scientific knowledge; they seemingly viewed 'laws' as permanent and unchangeable generalizations. Many teachers did not view curiosity as the fundamental driving force of science, rather they perceived the driving force of science as its connections to applications and development of useful technology. A situation could therefore be present in classrooms where science is presented as authoritarian, fixed, unchangeable, and non-tentative and thus perpetuating a situation where an inadequate conception of the nature of science is carried through courses of study. Further, such a situation would, generally, neither be supportive nor appropriate for science education especially the treatment of societal issues. Societal issues typically tend to be controversial and thus a perception of the teacher as a "know all" authority figure cannot be sustained. In dealing with societal issues such as environmental-conservation, some critical decisions are based on information other than ideal scientific evidence (Brunkhorst & Yager, 1990) a point that can be easily missed in an authoritarian classroom environment or when one holds an authoritarian view of scientific knowledge.

These observed inadequate conceptions are of particular concern because these inservice BEd teachers had already completed, successfully, the two professional courses, science curriculum theory and advanced level teaching methods which represented some of the areas of inservice training. Furthermore, in this study, scores on the two professional courses, Science Curriculum Theory and Advanced Level Science Methods, did not have a significant relationship with the academic content courses in science. Akindehin (1988), Ogunniyi (1983), and Mundangepfupfu (1988) suggest that appropriately designed teaching methods courses, e.g., those which deal with philosophical aspects of the nature of science result in teachers and students with a better and more accurate conception of the nature of science. This study found also that variables including region of origin, ethnic group, religious practice, mother or father's literacy, educational, or occupational levels, and whether they grew up in urban or rural settings were not found to have a substantive or meaningful relationship to the teachers' perception of the constructs measured in this study. The BEd scores had very little meaningful relationship to scores on the nature of science. It is therefore possible that depressed scores and misconceptions on the nature of science and scientific knowledge could be accounted for by science teacher education curricula especially the BEd program. The BEd program emphasizes the acquisition of science content and may not incorporate enough philosophical aspects of the nature of science. Since socio-cultural environment variables do not account for the teacher perceptions, perhaps their curriculum did. This study raises a possibility that courses in the BEd program need to be appraised so that at the very least they contribute to the overall value of inservice training as measured by the overall BEd score.

BEd science teachers' perceptions concerning a science and technology related societal issue reflected the impression about science and technology articulated in national policy documents and curricula. In these documents there is an obvious inclination to interchange acquisition of scientific world-view with modernization and hence with social and economic development. This national expectation for science and technology to improve the material and technological condition of the nation is manifest in the BEd science teachers' perceptions of the nature of science. For example, on the Kimball model (1967), the BEd science

teachers associated science with practical applications and with the development or production of useful technology or to improve human welfare. This conclusion was also reached by Cobern (1989) with a sample of Nigerian preservice teachers. It is necessary to take heed of the postulated consequences this might have on the perceptions of teachers and hence in science education. For example, Bloom (1989) conjectured that the belief that science is geared towards the development of technology and improvement of quality of life can lead to a belief that separates humankind from the rest of the natural world and hence to a "lopsided approach to making decisions about environmental and technological issues" (p. 413). On the other hand, Cobern (1989) notes that the belief and/or acceptance of science in 'development' can raise unrealistic expectations for science on the part of society in general. Science could be rejected in the future when the public finds that science fails to deliver useful technologies and goods or satisfactory solutions to emergent societal issues. Results obtained with this sample suggest that although BEd science teachers perceive science and technology as useful to society they also had some disillusionment and lack of optimism about the ability of science and technology to address social and environmental problems.

Further implications of societal expectations raised by the national plans may be their possible connection to science teachers' views concerning the nature of science. For example, BEd science teachers in this study did not view curiosity as the fundamental driving force of science, rather they perceived the driving force of science as its connections to applications and development of useful technology. Inadequate perceptions are likely to have consequences which must be investigated to find out their implications for the attainment of scientific literacy. Science perceived as a technology has been speculated to cause African science students to remain perplexed by the inner spirit of science (Odhiambo, 1968; p. 39). Another concern is that an emphasis on the applications of science could lead to teaching emphasis on the content of science at the expense of the processes of science (Cobern, 1989). Cobern proposed, and I concur, that a focus on applications should be based "on an accurate knowledge of the scientific enterprise and its very complex relationship with technology" (p. 539).

Conclusion

Overall, this study articulated the importance and relevance of understanding teachers' socio-cultural backgrounds, knowledge and beliefs on science education. It also raised attention to the urgent need for studies which explore how teachers deal with contradictions between science and indigenous culture or how teachers can be effectively assisted to do so. Research should attempt to understand the ways and the extent learning outcomes in science education are influenced by traditional world-view and how science education can be used as a vehicle to integrate the two systems of knowledge. However, further research must be designed cognizant of the need to overcome some of the limitations of the present study and to produce more generalizable data. For example, there is need to employ methodologies which overcome limitations associated with the use of surveys (Ary, et al., 1990) where respondents may not accurately report their perceptions and beliefs. Therefore, triangulation with observation data is necessary. Further research must try to establish a model of causal relationships between socio-cultural variables and science education and validate them with observations on how science teachers implement their knowledge and beliefs in classrooms. This study demonstrated existence of some discrepancy between views of science held by science teachers and those expressed in accepted models of the nature of science.

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