Interaction of socio-cultural backgrounds and beliefs with conceptions of the nature of science, societal issues, and instructional ideology among secondary science teachers in Zimbabwe

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Interaction of socio-cultural backgrounds and beliefs with conceptions of the nature of science, societal issues, and instructional ideology among secondary science teachers in Zimbabwe

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Iowa State University, 1994
Interaction of socio-cultural backgrounds and beliefs with conceptions of the nature of science, societal issues, and instructional ideology among secondary science teachers in Zimbabwe

by

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A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY

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1994
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CHAPTER I. INTRODUCTION

This study measured secondary science teachers’ conceptions and beliefs concerning the nature of science and scientific knowledge, science-related societal issues, instructional ideology, and traditional culture in Zimbabwe. The 63 teachers were enrolled in the Bachelor of Education (BEd) at the University of Zimbabwe in 1994. Although technically these teachers are students on the BEd program, they are referred to as "BEd science teachers" in the study. The study explored the science teachers' socio-cultural backgrounds as well as their level of commitment to indigenous cultural beliefs and values and how they interacted with science education. Relationships among teachers' socio-cultural backgrounds and orientation to indigenous culture and their perceptions on the nature of science and scientific knowledge, on a societal issue, and on instructional ideology were explored.

Background to the problem

Snow (1961) more than three decades ago described "the gulf of mutual incomprehension" between the scientifically literate and the non-scientifically literate. More recently, the National Commission on Educational Excellence (1983) in the USA reported that "there is a growing chasm between a small scientific and technological elite and a citizenry of ill-informed, indeed uninformed, on issues with a science component" (p. 10). In order to narrow this chasm it is essential to provide a general education in science for all so that a greater segment of society can attain scientific and technological literacy. The goal of scientific and technological literacy is featured also in 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, defining scientific and technology literacy is neither easily done nor easily implemented. Several valid perspectives on science and technology literacy exist. For example, numerous researchers identify understanding the nature of science as perhaps its most important
dimension (Meichtry, 1993; Andersen, Samuel, & Harty, 1986; Lederman, 1992, 1986 & 1987; Rubba & Andersen, 1978; Kimball, 1967). The widely acclaimed *Project 2061: Science for all Americans* sets one of the benchmarks for science literacy as understanding nature of science (American Association for the Advancement of Science, 1989) [AAAS]. The AAAS defines the nature of science in terms of three literacy goals, understanding the scientific world view, understanding scientific inquiry, and understanding the scientific enterprise. Almost underscoring the importance of nature of science, the National Association for Research in Science Teaching (NARST) (Good, 1992) committed issue 4 of volume 29 of the *Journal of Research in Science Teaching* to "teaching about the history and nature of science and technology".

Others nominate understanding the interaction of science, technology and society as another major attribute of scientific literacy (Steiner, 1973; Hart & McLaren, 1978; Yager, 1992; Volk, 1984). For this group preparation for citizenship is a more valid perspective to modern science education. According to this perspective, an accurate portrayal of the nature of science requires recognizing that the progress of science and technology has social implications. This orientation accounts largely for the emergence of science–technology–society (STS) courses (Yager, 1992) in which issues such as conservation of the environment are commonly discussed. Steiner (1973) explains:

One identified area of societal concern with which we are typically confronted is that of man's [sic] total position in nature, especially as a result of his science and technology. This area includes such specific issues as man's utilization of natural resources, the population of the world, the pollution of the earth's environment, and the applications of technology. These and other issues are increasingly being linked directly or indirectly with science and technology, and therefore they must be regarded with more than passing interest by science educators. (p. 417)

Global concern for the environment was heightened by the Tbilisi Declaration which recommended objectives of environmental education to include development of knowledge, awareness, and sensitivity to the environment and its problems, and acquisition of skills, attitudes, and motivation for participation in identifying and resolving environmental problems (Volk, 1984; p. 26). Steiner (1973) argued that societal issues 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). In Zimbabwe, for example, the current five year national development plan states that "development of science and technology is Zimbabwe's long term and most important strategy for economic and social development" (Government of Zimbabwe, 1991; p. 84). The National Research Council of Zimbabwe (1991) therefore suggests that in-service and staff development training of science and technical subject teachers is necessary so that they can respond effectively "to the scientific and technical emphasis urgently if Zimbabwe is to cope with the technological changes necessary for sustained economic growth and development" (p. 78). National school science syllabuses also underscore the importance attached to practical applications in addition to the development of a scientific world-view (Ministry of Education and Culture, 1992). For example, Core Science 5006, the compulsory and terminal science course at O level, and Extended Science 5007, the optional subject for preparing students for further education in science, emphasize practical applications of science in agriculture, in industry, in mechanical systems and in structures such as roof trusses and bridges, in energy uses, and in the health and development of the community. Syllabus documents articulate also the need to draw implications of science and technology to the social, economic, and industrial quality of life of local communities; this has been done by incorporating or infusing environmental and agricultural issues into science education curricula.

Although Cobern (1989) seemed to imply that science is the same wherever it is found, it appears from the preceding views that it is important to consider the socio-cultural context in which it occurs. In Zimbabwe a perception is created that science and technology can and should be concerned with practical applications and with production of useful technology. Cobern (1989) himself speculated that this societal expectation when based on an inadequate view of the nature
of science can lead to general disillusionment and rejection of science when it fails to deliver the goods. An African scholar Odhiambo (1968) noted that there is 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. Indeed, numerous researchers have noted 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; Gelfand, 1973). However, as Yakubu (1994) notes that this should not be construed to suggest that science and technology are incomprehensible to people in the developing countries, rather

The suggestion is that spontaneous application of the scientific spirit learnt through the western form of education is lacking. There seem to be something which inhibits the spontaneous application of scientific ideas in problem situations. 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)

This quote underscores the fact that traditional world-view is different from the scientific world view to be developed in science education. The *American Heritage* defines world-view as the "overall perspective from which one sees and interprets the world" and also as "a collection of beliefs about life and the universe held by an individual or a group" (p. 2058).

The importance of the traditional African world-view to science education in Zimbabwe needs to be explored. Personal experience and experience of others like Aschwanden (1982), Nelson (1982), Bourdillon (1987), Gelfand (1973), and Bozongwana (1983) to name a few, demonstrate that a scientific perception of reality is not part of the everyday cognitive and affective repertoire of many people in Zimbabwe. As noted by Yakubu and many others in comparable cultural contexts, the problem might lie in "indigenous cultural behavioral and thought patterns" which were different than in science. Although the goal of scientific and technological literacy in Zimbabwe is articulated in terms of the three valid perspectives noted in preceding sections, policy enunciation as well as educational research, fails to address how the world-view acquired in traditional culture is to be integrated with science education. In particular, the question should be asked
whether teachers have a commitment or not to indigenous cultural beliefs and values and how their socio-cultural backgrounds and beliefs are related to their understanding of the nature of science, science and technology related societal issues, and instructional ideology. This study was designed to address this concern. In particular it addresses questions such as these. What kind of socio-cultural environment did teachers grow up? To what extent were indigenous science teachers oriented towards indigenous culture? How do teachers perceive the nature of science and scientific knowledge? How do their perceptions compare to models of the nature of science and scientific knowledge and to perceptions of teachers in other countries? How do they perceive instructional ideologies? How do they perceive science and technology related societal issues concerning the environment? How are their orientation to indigenous culture and their socio-cultural backgrounds related to conceptions and awareness of the nature of science, instructional ideology, and societal issues?

It is conjectured that an inverse relationship exists between teachers' commitment or orientation to indigenous cultural beliefs and values and teachers socio-cultural backgrounds and their perceptions concerning the nature of science and scientific knowledge, science and technology related societal issues, and instructional ideology. This hypothesis assumes a positive relationship among nature of science and scientific knowledge, science and technology related societal issues, and instructional ideology. While this assertion is conjectural, it is supported by the nature of the socio-cultural context in which the study was conducted and by research evidence conducted predominately in western countries. In Zimbabwe, the scientific world-view has not become internalized to a point where it is spontaneously applied to problem situations. The following observations which may contradict outcomes desired in science education can be said about the socio-cultural context in which the study was conducted.

Sex role type education is based in the belief that social roles should be delineated by gender. Some claim that gender differentiation is practiced not "to prejudice the child against the other sex, but to let it grow naturally into its predestined role" (Aschwanden, 1982; p. 44). In
addition, for each person the functions in the family and in the kinship group are defined also according to age. At particular ages, the pre-specified functions are performed following a fixed code of manners and adhering strictly to the "correct" procedures laid down by tradition. There is always a strictly enforced correct traditional method or procedure for virtually all activities (Gelfand, 1965). Normal behavior is judged on one's adherence to the oral traditions and customs which require respect for the linear seniority hierarchy and subordination to traditional authorities or elders. Children, junior adults, and females are at the nadir of the seniority and/or privilege hierarchy and therefore cannot argue, query, or contribute to decision making in the family or community without specifically being asked to do so. It is generally inappropriate and disrespectful for them to query authority knowledge or decisions made by elders.

Traditional culture also differs substantially from science in the basic assumptions on which experience and phenomena are interpreted. Ancestors and other spirits directly or indirectly through their human hosts such as witches, magicians, and sorcerers can disrupt normal existence and create social tension for any of a number of reasons. This, combined with the perceived place of humans at the center of the universe, leads to interpretations of experiences which are deeply personalized, subjective and connected to the quality of people–people and people–spirits relationships (Bourdillon, 1987; Gelfand, 1973). These relationships are featured tremendously in people's perception of causality and causal relationships. As Gelfand notes, a subjective view of interpreting experiences makes the sustenance of social relationships vital "with an almost neglect of the material aspects of life" (Gelfand, 1973; p. 198). Sustaining harmonious relationships and avoiding social tensions is considerably more important than understanding relationships between inanimate objects. MacGaffey (1986) speculated on the possibility that preoccupation with sustaining social and spiritual relationships diminishes the potential for Africans to pursue natural science. A subjective interpretation of experience and phenomena contributes to a perception that everything has an underlying cause and an attitude that virtually everything can be explained.
Further, belief in cosmological causes or mystical explanations is supported and validated via top–down problem solving processes such as divination and revelation. Divination is thought to provide a means to acquire understanding of the nature of the problem and a sure means to provide a psychologically satisfying solution. In this case a spirit medium or diviner is consulted to make contact, receive, and communicate messages to and from the spirits thus enabling people to be given knowledge of things that would otherwise be difficult or impossible to know (Mbiti, 1990; p. 167). According to Kirby (1986) divination "offers the means of knowing what cannot be experienced empirically through the senses or deduced by logic" and therefore increases certainty and predictability about occurrence of life experiences (p. 105). MacGaffey (1986) speculated that diviners or healers may be regarded something like scientists since their role includes attempts to explain some part of experienced reality. These are some of the issues which define the worldview by which reality is experienced, perceived, and interpreted in traditional Zimbabwe. It was therefore expected that indigenous science teachers would have some inclination to indigenous cultural values and beliefs and that this orientation would have an inverse relationship to their perception of the nature of science, societal issues, and instructional ideology.

Research conducted mainly in the West also gives the basis to assume a direct positive relationship among understanding of the nature of science, instructional ideology, and understanding of science–related societal issues. Reviews of nature of science studies (Blakely, 1987; Meichtry, 1993; Lederman, 1992) demonstrate that these studies assume a direct positive relationship between teacher instructional behaviors and classroom environment hence student understanding of the nature of science. Tamir (1983) and Hodson (1988), for example, postulated that understanding the nature of science is related to teachers ability to distinguish between teaching science as inquiry or by inquiry. Chiapetta, Sethna and Fillman (1991) reported that teachers with weak or lack of understanding of the nature of science fail to develop science ideas and concepts which they teach around “the models that scientists used to form these concepts” (p.
940). This resulted in superficial and parsimonious treatment of both subject matter and the nature of science.

The preceding overview of indigenous culture suggests that people growing in it may be dogmatic and closed-minded. If that assumption is correct, then the results of western studies such as those of Jones and Harty (1978), Symington and Fensham (1976), and Lazarowitz (1973) can be extrapolated to the present context. Their studies examined the relationship between science teachers' instructional ideology and their dogmatism. Teachers who had a preference for inquiry created classroom environments which were more humanistic (Jones & Harty, 1978). Symington and Fensham (1976) found that closed-minded elementary teachers preferred obedient, quiet, reserved pupils who liked to work alone and who readily accepted judgment of authorities. Teachers' orientation towards inquiry and attitudes towards science as implied in curriculum materials was found to be negatively correlated to dogmatic scores. Teachers scoring high on dogmatic scales were more traditional in their beliefs about their classroom behavior and they exhibited less inquiry behaviors. Strawitz (1977) found that teachers who were less dogmatic were more likely to acquire attitudes and behaviors consonant with the philosophy of new science curricula. It is conjectured that these findings may be extended to other cultures whereby an authoritarian orientation of a culture could serve to influence teachers to have beliefs less inclined to inquiry teaching behaviors and thus provided some theoretical support for the hypothesis of this study.

Research in other non-western cultures, although scanty, provides additional evidence that an inverse relationship between one's commitment to a traditional world-view and one's orientation to the scientific world-view may be real. It is on such a belief that Cobem (1993) noted the need in developing countries to ask "questions about world-view and the compatibility of various non-western world views with modern science" (Cobem, 1993; p. 1). Indirect evidence is given by Morris (1983) who 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). The influence
and relationship of an African world-view to the scientific world-view is further demonstrated in
the following quote in which Shrigley (1983) recalls and describes his experience in a Nigerian
teachers' college:

I found students who were seeking simple answers to complex scientific phenomena,
distressed by the tentative nature of the scientific enterprise. There was a tendency to
embrace, even tongue-in-cheek, information having a superstitious base, but at least a
definite answer, in preference to wrestling with several scientific alternatives. To
illustrate the frustration that the lack of sure and fixed knowledge can generate, one
student made a public appeal that I teach only what scientists were sure of! (p. 427)

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 (Jegede & Okebukola,
1991). Jegede and Okebukola found that 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 high level of religious belief.

Except for the Jegede and Okebukola (1991) study, most of the research cited in this paper
appears to have reached conclusions and made conjectures about the influence of socio-cultural
environment based on pre-collegiate students who have, relatively, a limited exposure to science.
None of the studies makes reference to what the influence of an indigenous world-view might have
on indigenous teachers of science. Although they have tertiary level training in the teaching of
science, they would be expected to have orientation or commitment to some aspects of their culture-of-origin. Since world-view is a collection of beliefs about life and the universe held by an
individual or a group (American Heritage, 1992) it should be expected that the world-view
acquired from one's natural culture would be more persistent relative to the one acquired in school.
For example, both Ogawa (1986) and Ogunniyi (1988) observed that science, for many non-western
students is like a second culture. Perhaps 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, teachers' indigenous world-view is 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. It is expected that indigenous teachers are confronted on a day-to-day basis by contradictions between their own world-view and the scientific world-view as well as between the scientific world-view and their students' world-view.

Statement of the problem

This overview tried to show that scientific and technology literacy is a complex and multifaceted construct which has been defined in numerous ways. However for the purposes of this study, the broad view of the AAAS (1989) on the construct is adopted. According to AAAS (1989), the goal of scientific and technological literacy should be conceived in terms of categories of relevance such as understanding of the nature of science, understanding how scientists go about their work, and understanding the overarching ideas and concepts of science, applications of science and technology, appreciation of the social and economic implications of science and technology, and environmental implications of science and technology. It was assumed that these literacy areas constituted important areas of teacher knowledge. For example, teachers with less than adequate understanding of the nature of science are not likely to enable students to understand the nature of science or scientific knowledge (Lederman, 1992). Further a potential exists that their epistemological knowledge will be inadequate to present an accurate notion of the nature of science and scientific knowledge in particular its relationship to social issues or its characterization as a human endeavor (Duschl & Wright, 1989; Meichtry, 1993). Yager (1992) observed that societal issues can be useful to increase the relevance of science education to different cultural contexts and to students' personal lives. For example, authentic inquiry requires students to participate in real-life investigations in the natural environment in their communities (Burbules & Linn, 1991) and thus to see the connections of science to their cultural experiences which constitute everyday life. According to Volk (1984) environmental conservation represents a significant societal issue for which science educators should be accountable. In the context of Zimbabwe, the teachers knowledge of science, science-related societal issues, and science instructional styles are inevitably influenced
by their traditional cultural backgrounds especially by the extent to which they are committed to traditional world-view. It is imperative that we identify and help teachers understand at least the consequences of their indigenous socio-cultural backgrounds, beliefs, and values on their own actions and on their students. It is therefore assumed that a thorough grounding on the cultural context and indigenous world-view in which they teach so that they are better able to exemplify and link their subject domain to realities and everyday experiences of their students. They have to demonstrate to their students the strengths and weakness of traditional culture relative to science as a way of viewing the universe and as a way of knowing (Ogawa, 1986; Ogunniyi, 1988). Overall, science teachers should be aware of their own inclination and commitment to their indigenous culture and how this may be consciously or unconsciously interacting with their teaching and their students learning.

**Research questions**

This study attempted to integrate knowledge about science teachers' knowledge and beliefs on the nature of science, instructional ideology, societal issues, and knowledge about their indigenous culture or the socio-cultural beliefs and values they might hold by seeking an answer to the broad question:

What is the relationship among indigenous Zimbabwean secondary science teachers' conceptions and awareness of the nature of science, societal issues, science instructional ideology, their socio-cultural backgrounds, and their orientation to indigenous cultural beliefs?

Specifically, the study sought to provide answers to the following research questions.

1. What are the personal characteristics (e.g. sex, gender, etc.) and the academic, professional, and socio-cultural backgrounds of BEd science teachers?

2. What kind of socio-cultural environment constitutes indigenous culture in Zimbabwe?

3. What is the perception and experience of science teachers concerning the interaction of indigenous traditional culture and science education?

4. To what extent are BEd science teachers oriented to indigenous culture?

5. What are the implications of indigenous culture and world-view to science education?
6. What is the perception of BEd science teachers on the nature of science and on the nature of scientific knowledge?

7. How do BEd science teachers' perceptions compare (i) to models of the nature of science and scientific knowledge, and (ii) to perceptions of teachers in other countries?

8. What is the level of awareness of BEd science teachers on a societal issue, environmental conservation?

9. What is the instructional ideology preference of BEd science teachers?

10. What are the relationships among science teachers' orientation to indigenous culture, instructional ideology, environmental conservation awareness, and understanding of the nature of science and scientific knowledge?

11. Are there differences in science teachers' orientation to (i) indigenous culture, (ii) instructional ideology, (iii) environmental conservation, and (iv) to the nature of science when they are grouped according to personal characteristics, e.g., gender, age-group, etc., academic, professional, and socio-cultural background variables?

In order to provide answers to these questions, the questionnaire survey technique and the focus group interview were employed. The questionnaire booklet administered to the science teachers consisted of previously validated scales or their close adaptation. Only the scale measuring teachers' orientation to indigenous culture (OICS) was totally researcher-developed. In addition to the survey, the science teachers' perception of the nature of interaction of indigenous culture with science education was assessed by conducting a structured content analysis of written responses to an open ended question (Tesch, 1990) and via a random sample 14 member semi-structured focus group interview technique (Krueger, 1988). In general, an inverse relationship was predicted between socio-cultural variables and an orientation to indigenous culture and knowledge concerning the nature of science and scientific knowledge, science and societal issues, and instructional ideology. Specific hypotheses to each question are stated in Chapter III. All hypotheses were tested by relevant inferential statistics after being transformed into their null (H₀) form and at the .05 level set a priori (Hinkle, Wiersma, & Jurs, 1988).

Significance of the study

This investigation endeavored to expand and amplify work on the relationship of teachers' socio-cultural characteristics and orientation or commitment to their indigenous culture and their
conceptions regarding philosophical, sociological, and pedagogical aspects of scientific knowledge. Determining their perceptions was significant since their beliefs concerning the subject matter, pedagogical practice, and societal context were expected to influence the nature and quality of learning their students acquired and in the long term perceptions and attitudes which the general populace in society would most likely possess. What we already know about African science teachers especially their culture of origin beliefs and factors is limited and often conjectural. For example, Shrigley (1971), writing about his two year experience in a Nigerian college was remarkably surprised at the obvious differences between his American perspective and perspectives of his African student teachers. He says that he learned quickly that in teaching indigenous African students he had to deal with their strongly held ideas and beliefs as well as with their superstitions. He says:

Students were inclined to view science as final and fixed. Some of the most uneasy moments developed when dealing with problems having only tentative answers. In desperation, one keenly-interested science student stood beside his desk and in typical African politeness asked, "Why don't you teach only what scientists are sure of?". It is my conviction that many traditional explanations to natural phenomena are, in part at least, the result of this uneasiness sensed by the African when a phenomenon goes unexplained. Even a tongue-in-cheek explanation seems better than no explanation at all. (pp. 211-212)

In addition to a growing body of research cited in Chapter II, this personal experience and interpretation of the way African students learned science obviated the potential significance of the influence of culture-of-origin factors, knowledge, and beliefs. The study provides teachers and teacher educators with knowledge on the interaction of socio-cultural variables with science education. This knowledge is essential to reverse the general low interest and achievement of students in science as well as the current low levels of scientific literacy in societies such as in Zimbabwe where the traditional world-view is dominant. This study attempted to close the knowledge void created by the general paucity of studies integrating teachers' knowledge and beliefs concerning indigenous culture, nature of science, science-related societal issues, and instructional ideology.
Further, information obtained in this study was particularly pertinent for the in-service training of teachers when it is considered that over 95% of Zimbabwe's compliment of teachers are trained in non-graduate colleges of education where they receive the certificate of teacher education. A major route by which teachers can obtain a degree level qualification is through the in-service Bachelor of Education (BEd) program at the University of Zimbabwe, to which only a minuscule of serving teachers are selectively admitted. For science teachers, enrollment in the program can provide a means by which they develop a deeper understanding of the scientific enterprise, its methods, processes, content, and pedagogical base. The information gathered in this study can be used to appraise the BEd science education program.

Research concerning teachers' conceptions of the nature of science in the past has been predominantly in North America and generally involved determining whether their conception was adequate or not (Lederman, 1986). Although science is claimed to be "similar no matter where it is found" (Cobern 1989; p. 538), no evidence exists involving direct assessment of teacher understanding and knowledge of the nature of science relative to accepted models in Africa in general and Zimbabwe in particular. In particular only one African country, Nigeria, was involved (Cobern, 1989; Akindehin, 1988), raising the need for cross-cultural comparisons. It was of interest to replicate studies such as that of Cobern (1989) whose conclusion concerning perception of scientists and the nature of science among Nigerian teachers raises the possibility that Zimbabwean teachers might also have perceptions of science at variance with accepted models. Nigerian teachers were reported to perceive scientists as secretive and nationalistic and that "their sense of the nature of science was that science is primarily for the development of useful technology" (pp. 537-538). Zimbabwe expects to utilize science and technology in order to bring about social and economic transformation and thus the curriculum tends to depict emphasis on practical applications. It is important that such a decision be based on an accurate understanding of the scientific enterprise and its complex relationship with technology and development as proposed by Cobern (1989); and hence the significance of determining science teachers' orientations in the present study.
This study also utilizes instruments generally accepted as good measures of the nature of science and scientific knowledge outside of the context in which they were developed and thus help to assess their cross-cultural validity and generalization. Previous studies merely evaluated and inferred a relationship between the knowledge level of teachers regarding the nature of science and instructional ideology without measuring the constructs with the same sample. This study went further to ascertain whether instructional preferences of teachers or how they were likely to deliver science instruction and how they perceived a societal issue, environmental conservation were commensurate with accepted models of the nature of science. It therefore provided some integration as well as holistic interpretation of the results in a manner which took into consideration the socio-cultural backgrounds and beliefs of science teachers.

Finally, local scholars in Zimbabwe are raising issues concerning the scientific enterprise as a way of knowing and its relationship or lack thereof with indigenous knowledge systems (Mundangepfupfu, 1988; Muchena, 1990). This study touched on the indigenous knowledge system problem by focusing on teachers' commitment to Zimbabwe's traditional culture and how it might relate to their conceptions of the nature of science and scientific knowledge, instructional ideology, and societal issues. The study articulates aspects of traditional culture that may interact with science education to facilitate or to hinder the students long term adoption of scientific knowledge, methods, and processes and therefore as a useful starting point for developing new approaches including those that might take into account the indigenous knowledge system. It was noted earlier that UNESCO advisors observed that many African children do not have a lasting commitment to science (Morris, 1983). This study contributes to the pool of knowledge necessary to raise and to maintain at a high level student interest in science during and after duration of courses of study, a process in which teachers are major players. This line of research is relevant to science teacher education and to school science education where information is generally needed to effect curriculum innovation and change. In order for a scientific world-view to be acquired and adopted for problem solving, Mundangepfupfu (1988) suggests that:
A more systematic approach to curriculum decision making based on the curricular concerns of science educators in Africa is needed. One of these concerns is the existence of magico-traditional beliefs. It seems that without a non-partisan systematic distinction of magico-traditional beliefs from scientific beliefs science educators will remain largely ineffective in their attempts to inculcate the scientific world-view through science teaching although students may be indoctrinated. (p. 11)

Concerns of science educators must certainly include how to maximize the opportunity for students to attain a scientific world-view. Mundangepfupfu (1988) surmised that the science methods courses should go beyond methods of teaching to an understanding of the epistemological basis of knowledge, in this case understanding the nature of scientific and indigenous knowledge, beliefs and values. This study collected information on dimensions such as teachers' personal orientation to indigenous culture and understanding of the nature of scientific knowledge that may help in efforts to make the curriculum and teaching more relevant to Zimbabwe.

One of the challenges facing government as the primary sponsor of education is how to improve the quality of science teaching in schools (Government of Zimbabwe, 1991; p. 82). The National Science Board (NSB) (1985) in the USA suggested that in order to address such challenges, "it is especially important to study the present conditions to provide benchmarks for measuring changes" (p. 25). This study provided some baseline information which may be used as a benchmark to appraise current science teacher education methodology courses at university level and in the colleges of education (alternatively known as teacher training colleges). Overall, the study was anticipated to impact educational development in Zimbabwe in at least three ways. First by providing baseline data on which to appraise the impact of a science teacher education or BEd program and to provide indications of the direction curriculum development should take on relevant local and global issues. Second, by providing information on which to base staff development and training of science educators. Third, by raising the level of awareness of science teachers and educators to the influence and relevance of culture-of-origin backgrounds, knowledge, and beliefs on science education.
Assumptions of the study

Several assumptions were made in designing the study. First, it was assumed that understanding the nature of science and societal issues such as environmental conservation awareness are important and relevant attributes of the construct scientific literacy in Zimbabwe. The two scales used in the study, Kimball's (1967) nature of science survey (NOSS) and the Rubba-Andersen's (1978) nature of scientific knowledge scale (NSKS), were assumed to be both valid and reliable. A positive relationship between scores on the two measures was expected. It was assumed that these scales helped to identify teachers' epistemological views on the nature of the scientific discipline and that doing so was a significant endeavor. Lyons (1990) noted that the teacher's assessment of how to present subject matter is mediated in part by their epistemological knowledge. Along the same vein, Edmondson and Novak (1993) stated that identifying the epistemological positions of both teachers and students is "an important part of understanding the teaching and learning process" (p. 549).

Second, the predominant models of the scientific enterprise lead to the assumption that inquiry approaches in science instruction are more desirable than non-inquiry techniques of science instruction. In order to obtain a measure of instructional preference, it was assumed that the science teachers ideological scale (STIPS) (Jones & Harty, 1978) is a valid and reliable scale for discriminating between science teachers with a preference for inquiry approaches and those with a preference for non-inquiry approaches. A teacher's conception of the nature of science and scientific knowledge is assumed to be an important factor influencing teaching behavior and instructional preferences (Pichard, 1988; Shavelson & Stern, 1981). These teacher behaviors and instructional preferences are assumed to influence the views and perceptions students acquire regarding the nature of science and science-related societal issues. Understanding the nature of science and scientific knowledge was presumed an important condition in deciding and developing science curricula which focus on practical or applied aspects of science and technology (Cobem, 1989).
Third, it was assumed that environmental conservation was a significant science-related societal issue in Zimbabwe. This assumption is based on the observation that environmental conservation themes and topics were infused into the school science syllabuses (Ministry of Education and Culture, 1992). Further, it was necessary to assume that the environmental conservation awareness scale (ECAS), which was adapted based on the work of Steiner (1973) and Richmond (1976), was valid and reliable.

The fourth assumption concerned response sets and disposition of the respondents to scales in the study (Borg & Gall, 1989). It was assumed that secondary science teachers would understand factors defining the three constructs nature of science, environmental conservation awareness, and instructional preference, and report them honestly. Misunderstandings or misconceptions regarding the nature of these constructs were assumed to be identifiable and that these misconceptions could be corrected or remedied by appropriately focused instruction (Lederman, 1992). Finally, it was assumed that science teachers would be aware of their commitment to indigenous culture and how specific aspects of indigenous world-view interacted with science education. Their orientation to indigenous culture was assumed to be related to their perception of the nature of science, environmental conservation, and instructional ideology. It was assumed that the orientation to indigenous scale was a valid and reliable measure of science teachers commitment or non-commitment to traditional values and beliefs.

Limitations of the study

This descriptive correlational study used the questionnaire survey and focus group interview techniques to collect data. It is expected that some of the limitations associated with these designs and techniques (Borg & Gall, 1989; Ary, Jacobs & Razaveih, 1990) apply to this study. It is important that when interpreting the results of this study the following specific limitations be borne in mind.

1. The study surveys a relatively homogenous select group of teachers who are studying for the Bachelor of Education degree. In Zimbabwe, pre-service science teacher training and the
majority of in-service programs are at the non-graduate level. Graduate science teachers represent only a small percent, perhaps <10%, of certified science teachers. The results may not generalize to all secondary science teachers in Zimbabwe.

2. Respondents may not accurately report their perceptions and beliefs (Borg & Gall, 1989). The questionnaire was lengthy which could have affected the response sets of the respondents.

3. Science and technology have not become widespread to the extent of being integral parts of everyday life in Zimbabwe and thus the potential exists that indigenous world-view might confound science teachers' responses in ways not predicted in the study.

4. The nature of science (Kimball, 1967) or the nature of scientific knowledge models (Rubba and Andersen, 1978) represent only some of several possible models for describing the nature of science and scientific knowledge. These and the other scales were assumed to be relevant and discriminating with the sample used in the study.

5. No treatment variables were manipulated, therefore correlations and relationships reported are non-causal (Borg & Gall, 1989).

6. The researcher adapted environmental conservation awareness scale and the researcher developed orientation to indigenous culture scale were not pre-tested. Validation work is planned as an immediate extension of this research.

**Definition of terms and constructs**

The terms “scientists” and “science” in this research are used with reference to “natural scientists” or “natural science” unless otherwise stated. Many researchers agree that the theoretical basis for the nature of science and scientific knowledge research is well laid out in numerous studies but that different models are applicable to studying this aspect of scientific literacy (Pichard, 1988; Meichtry, 1993; Lederman, 1992). Two models which have been used extensively in the past to denote the nature of science (Kimball, 1967) and scientific knowledge (Rubba & Andersen, 1978) were selected for use in the study. Kimball's model is a generalized eight point model which seeks to show the fundamental driving force of science, science as a process,
parsimony, methods of science, attributes of science, and tentativeness of knowledge. The nature of scientific knowledge model is a six factor model designed to show the amoral, creative, developmental, parsimonious, testable and unified nature of scientific knowledge (Rubba & Andersen, 1978). Foundation aspects related to instructional preferences are laid in the Jones-Harty (1978) study and those on environment awareness on numerous sources including Richmond (1976), Hart and McLaren (1978), Steiner and Barnhatt (1972), Steiner (1973), and Volk (1984). The potential influence of socio-cultural factors are described in Ogawa (1986), Ogunniyi (1988), Jegede and Okebukola (1991a & 1991b), Prophet (1990), McKinley, et al., (1992), and more recently by Barba (1993). The following operational definitions which are elaborated further in later chapters were adopted in this study.

1. **Nature of science**: the methods, processes, and aims of science as well as the professional structure in which scientists operate (Blakely, 1987).

2. **Understanding of the nature of science**: a score indicating knowledge of the methods, processes, and aims of science as well as the professional structure in which scientists operate as measured by Kimball's (1967) scale.

3. **Understanding of the nature of scientific knowledge**: a score indicating knowledge of the amoral, creative, developmental, parsimonious, testable, and unified nature of scientific knowledge as measured on the Rubba–Andersen (1978) scale.

4. **Instructional ideology preference**: a score which reflects an ideological orientation towards either inquiry or non-inquiry instructional approaches on the science teachers ideological preference scale (Jones & Harty, 1978).

5. **Environmental conservation awareness**: a score which reflects teacher awareness of environmental conservation on a researcher adapted environmental conservation awareness scale.

6. **Indigenous traditional culture**: the general values, morals, customs, beliefs, and knowledge associated with indigenous Zimbabweans of Shona and Ndebele origin.
7. **Indigenous world-view**: the overall perspective and the collection of beliefs about life and the universe held by an individual or a group in traditional society.

8. **Orientation to indigenous culture**: a score on a researcher-developed scale showing the extent of a respondent's personal identification one feels towards African traditional beliefs, customs, lifestyle, and/or values.

**Explanation of the dissertation format**

This dissertation is organized into eight chapters. This chapter presented the background to the research problem, the research questions, significance, assumptions and limitations of the study, and it defined the terms and constructs representing variables in the study. Chapter II reviews literature related to the nature of science, instructional ideology, societal issues, and socio-cultural variables in science education. Chapter III presents a summary and overview of the research design and methodology. Chapter II and Chapter IV through Chapter VII are manuscripts of papers submitted or to be submitted to science education journals for publication. Chapters II, IV, V, VI, and VII are self-sufficient in that each of these chapters is a complete manuscript consisting of title, abstract, literature review, statement of problem, methodology, results, conclusions and discussion, and a complete list of references. Tables and references listed in each of these chapters are numbered sequentially from 1. Chapter IV describes the indigenous world-view and teachers' qualitative assessment of its interaction with science education. Chapter V describes the orientation of science teachers to indigenous culture and its relationship to instructional ideology. Chapter VI describes science teachers' perception of the nature of science and scientific knowledge and instructional ideology. Chapter VII describes science teachers' awareness of a science and technology related societal issue, environmental conservation. Chapter VIII contains a summary and discussion of the findings as they apply to the larger problem presented in Chapter I. A bibliography of the literature cited in Chapter I, III, and VIII, acknowledgments, and appendices are then given.
Explanation of conceptual linkage among dissertation papers

Organizationally, as presented in the preceding section, the constructs of the study are treated in depth in the individual chapters. However, it must be clarified that the significance of the study lies in its emphasis on the interaction and connections among the teachers' culture-of-origin beliefs and world-views and conceptions of the nature of science, science and technology related societal issues, and science instructional ideology. In line with an "interactionist" approach (Bloom, 1989), analysis and discussion of the results in each chapter involves exploration of the connections among constructs as seen by teachers in the study and as denoted in correlation matrix data. An "interactionist" approach, as demonstrated in the Bloom (1989) and Aguirre, Haggerty, and Linder (1990) articles, is relevant to the African context such as the one in which the study was conducted. In such a context, it has been suggested that deliberate efforts are essential to integrate the indigenous thought and belief patterns with the scientific world-view (Yakubu, 1994). In this regard, a useful starting point may be determining knowledge and beliefs teachers presently have concerning science and their cultural world-view.

Unlike in several previous studies, this study simultaneously measures conceptions of the nature of science, science instruction, and their awareness of science and technology related societal issues with a single sample of science teachers; these areas of teacher knowledge and belief represent three dimensions on which to evaluate the way they viewed science. Many of the previous studies were also largely concerned with identifying the adequacy of teacher conceptions of the nature of science or instruction relative to the models on which measured (Lederman, 1992); they identified and described the "misconceptions" teachers or their students had. The present study went a little further to identify the socio-cultural factors and aspects of traditional world-view and knowledge which may serve as sources of teachers' "alternative" conceptions and/or "misconceptions" about the nature of science or instruction. Studying the interaction among these constructs and variables is relevant in attempting to comprehend the indigenous teacher's role in the adoption and utilization of the scientific world-view in non-western traditional environments.
CHAPTER II. INTERACTION OF TRADITIONAL SOCIO–CULTURAL VARIABLES WITH INSTRUCTIONAL IDEOLOGY AND KNOWLEDGE OF THE NATURE OF SCIENCE: A REVIEW OF THE LITERATURE WITH IMPLICATIONS FOR ZIMBABWE

Paper submitted to the Zimbabwe Journal of Educational Research

Overson Shumba

Abstract

This article is a review of the literature dealing with the construct science and technology literacy as it relates to teacher knowledge and beliefs regarding the nature of science and scientific knowledge, science and technology related societal issues, science instructional ideology, and traditional culture. The article seeks to demonstrate the relevance of socio–cultural contexts and variables by reviewing aspects of the traditional culture of a developing country, Zimbabwe. It is postulated that an inverse relationship exists between teacher orientation or commitment to traditional world–views and socio–cultural backgrounds and their perception concerning the nature of science, science and technology related societal issues, and science instructional ideology. The postulated relationship has implications for the effective adoption and integration of a scientific world–view into the cognitive and affective repertoire of indigenous students so that it may be spontaneously utilized in problem situations which is currently lacking.

Introduction

Snow (1961) more than three decades ago described "the gulf of mutual incomprehension" between the scientifically literate and the non–scientifically literate. He said then:

They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground. ... The non–scientists have a rooted impression that scientists are shallowly optimistic, unaware of man's condition. (Snow, 1961; pp. 4–5)
More recently, the National Commission on Educational Excellence (1983) in the USA reported that "there is a growing chasm between a small scientific and technological elite and a citizenry of ill-informed, indeed uninformed, on issues with a science component" (p. 10). These observations made in the context of developed western countries demonstrate that science as a culture was being conceived as different from the culture of ordinary citizens. In developing non-western countries the gulf could be wider and indeed it has been observed that science is a second culture for many indigenous students (Ogawa, 1986; Ogunniyi, 1988). Regardless of the hemisphere to which nations belong, it is generally conceived that in order to narrow this chasm it is essential to provide a general education in science for all so that a greater segment of society can attain scientific and technological literacy. The goal of scientific and technological literacy is featured also in 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). This article seeks to assess perspectives and views concerning the construct science and technology literacy and its relevance to a predominantly traditional non-western culture. It delineates understanding of the nature of science, science-technology societal issues, and instructional ideology as important areas of science teacher knowledge. Analysis of the literature leads to a conjecture that these dimensions of teacher knowledge and belief must be studied in relation to socio-cultural variables and indigenous traditional world-view if effective integration of the traditional world-view and the scientific world-view is to take place. Following a description of traditional culture in Zimbabwe, a hypothesis is formulated that an orientation to indigenous culture has an inverse relationship to conceptions of the nature of science, science-technology related societal issues, and inquiry instructional ideology.

Some notions of the nature of science

One of the difficulties in implementing programs to achieve scientific and technological literacy, in both developing and developed countries, is admittedly the abstractness and multifaceted nature of the construct. In this article the nature of science and technological literacy
is highlighted by examining goal proclamations published in the past few decades. For example, the National Science Foundation (NSF) funded Project Synthesis in 1981 recommended that science education should prepare individuals to utilize science for improving their own lives, for coping with an increasingly technological world, for dealing responsibly with science–related societal issues, and for pursuing science academically as well as professionally (Yager, 1992; p. 908). These goals were endorsed by the conferees of Exeter II (Brinkerhoff & Yager, 1986; p. 10). In the context of Africa several reviews are illuminating (Chisman, 1984; Morris, 1983; Nichter, 1984; Ogunniyi, 1986); their reviews suggest that the goals of science education in Africa are relatively similar to those in developed western countries. Ogunniyi (1986) illustrates the resemblance in the following summary.

(1) the development of a spirit of inquiry; (2) the understanding of valid views of the nature of science, i.e., its tentative and revisionary character; (3) the teaching of problem-solving using scientific techniques, namely, observation, measurement, formulating and testing hypotheses, experimentation, drawing valid conclusions, etc.; (4) impartation of scientific literacy; (5) development of manipulative skills and scientific attitudes; (6) understanding the interaction between science and society; (7) the transformation of the environment; (8) the production of individuals who are capable of participating in socially useful and productive activities; the production of citizens who are better consumers of scientific products; (10) accelerating the development of potential scientific and technological manpower; etc. (Ogunniyi, 1986; p. 116)

An analysis of the curriculum in Zimbabwe indicates that similar goals are featured but with greater attention being paid to raising student appreciation of the role and importance of science both in the workplace and in the community (Ministry of Education and Culture, 1992). Curriculum innovation as demonstrated in the compulsory course, Core Science 5006 and the optional subject, Extended Science 5007, place a high premium on practical applications in agriculture, in industry, in mechanical systems and in structures such as roof trusses and bridges, in energy uses, and in the health and development of the community. The curriculum also seeks to develop a scientific world-view by attempting to instill the qualities of objectivity, impartiality, a critical approach to information and ideas, and a respect for the virtues of incisiveness and the
quality of evidence (Ministry of Education and Culture, 1992). These scientific habits of mind as noted by the AAAS (1989)

... can help people in every walk of life to deal sensibly with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty; without the ability to think critically and independently, citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems. (p. 13)

These summary statements concerning outcomes desired in science education are often taken at face-value in spite of their complexity. Their abstractness can be demonstrated for example with reference to the goal of "understanding of valid views of the nature of science" which numerous researchers project as perhaps the most important dimension of scientific literacy (Meichtry, 1993; Andersen, Samuel, & Harty, 1986; Lederman, 1992; Rubba & Andersen, 1978; Kimball, 1967). Numerous studies including research by Andersen, et al. (1986), Meichtry (1993), Rubba and Andersen (1978), and Kimball (1967) were designed around the assumption that understanding the nature of science is evidence of scientific literacy. In the NSTA's Scope, Sequence and Coordination Project it is recommended that teachers should emphasize the nature of science as a human enterprise (Pearsall, 1992; p. 16) and the internationally acclaimed Project 2061: Science for all Americans sets one of the benchmarks for science literacy as understanding the nature of science (American Association for the Advancement of Science, 1989) [AAAS]. Almost underscoring the importance of nature of science, the National Association for Research in Science Teaching (NARST) (1992) committed issue 4 of volume 29 of the Journal of Research in Science Teaching to "teaching about the history and nature of science and technology" (Good, 1992).

As further demonstration of the complexity alluded to, there are several models of the nature of science and of the nature of scientific knowledge (Meichtry, 1992). The Project 2061 model depicts the nature of science in terms of the three literacy goals, understanding the scientific world view, i.e., the world is understandable, scientific ideas are subject to change, scientific knowledge is durable, and science cannot provide complete answers to all questions; scientific methods of inquiry, i.e., science demands evidence, science is a blend of logic and imagination, science explains and
predicts, scientists try to identify and avoid bias, and science is not authoritarian; and nature of the scientific enterprise, i.e., science is a complex social activity, science is organized into content disciplines and is conducted in various institutions, there are generally accepted ethical principles in the conduct of science, and scientists participate in public affairs both as specialists and as citizens (AAAS, 1989; pp. 25-31). On the AAAS' (1989) model, the nature of scientific knowledge is a component of the broader construct "nature of science". In the Kimball (1967) model the nature of science is characterized in terms of eight assumptions such as curiosity drives science; science is a process oriented, dynamic, and ongoing activity rather than a static accumulation of information; science is parsimonious, has as many methods as there are practitioners, is open, revisionary, tentative, etc. The Rubba and Andersen (1978) model of the nature of scientific knowledge describes scientific knowledge as amoral (scientific knowledge cannot be judged as good or bad), creative (scientific knowledge is a product of the human intellect), developmental (scientific knowledge changes over time), parsimonious (scientific knowledge tends toward simplicity), testable (is capable of public empirical test), and unified (various specialized sciences contribute to laws, theories, and concepts which help to understand the unity of nature) (Rubba & Andersen, 1978; p. 450). Both the nature of science and the nature of scientific knowledge are built on similar understandings and are valid (Meichtry, 1993). However, the nature of science is broader and includes aspects on the nature of scientific knowledge, nature of the scientific enterprise, and nature of scientists as demonstrated by the Kimball (1967) and AAAS (1989) models. The Rubba-Andersen model is more specific to the nature of scientific knowledge, it focuses on the nature of scientific ideas and claims, the products of scientific activity. An assumption about appreciation of the nature of science is that it contributes to a person's scientific literacy. Meichtry's (1993) review demonstrates that accepting the tentative, developmental, and revisionary character of science helps dispose of authoritarian tendencies and cynicism associated with a view of science as a collection of unchanging facts. Appreciation of the nature of science also provides the intellectual tools to assess the validity of evidence and the logic of arguments.
The preceding review tried to show that understanding the nature of science is one attribute of scientific literacy. Another valid perspective on scientific literacy concerns understanding the interaction of science, technology, and society (Steiner, 1973; Hart & McLaren, 1978; Yager, 1992; Volk, 1984). For this group, preparation for citizenship is a valid perspective to modern science education. According to this perspective, an accurate portrayal of the nature of science requires recognizing that the progress of science and technology has social implications (Yager, 1993; Brunkhorst & Yager, 1990). This orientation accounts largely for the emergence of science–technology–society (STS) courses (Yager, 1992) in which issues such as conservation of the environment are commonly dealt. Steiner (1973) explains:

One identified area of societal concern with which we are typically confronted is that of man's [sic] total position in nature, especially as a result of his science and technology. This area includes such specific issues as man's utilization of natural resources, the population of the world, the pollution of the earth's environment, and the applications of technology. These and other issues are increasingly being linked directly or indirectly with science and technology, and therefore they must be regarded with more than passing interest by science educators. (p. 417)

Concern for the environment led to the Tbilisi Declaration which recommended that educators should be concerned with developing among students knowledge, awareness, and sensitivity to the environment and its problems, attitudes, concern, and skills requisite for participation in environmental improvement/protection and for identifying and resolving environmental problems (Volk, 1984; p. 26). In a similar stance the Council for Environmental Quality (1992) in the USA advised that environmental educators should instill among young people an environmental ethic which will prepare them to deal responsibly with environmental issues throughout their lives and that they should raise the environmental awareness of adults "as informed consumers in the global shift toward sustainable development and pollution prevention" (p. 60). Regardless of their later academic or professional specialization, students should develop social values and strong feelings of concern for the environment and the skills and desire to resolve those issues (Derkach, 1990; p. 162). Part of the strategy in Zimbabwe for making science education relevant has been through the infusion of environmental and agricultural issues into curricula
In primary school, the subject offered to all students is "Environmental and Agricultural Science". At Ordinary level, Science 5006 and 5007 have as their longest theme "Science in Agriculture" which deals extensively with environmental conservation issues, especially land management (Ministry of Education and Culture, 1992). Environmental education components occur also in the school syllabi for three other subjects, agriculture, geography, and education for living (Muchena, 1990). Incorporating or infusing environmental and agricultural issues into science education curricula appears to be appropriate curriculum innovation within the purview of citizenship preparation. Volk (1984) explains that both environmental and science education are concerned with the development of individuals who are knowledgeable about science-related societal issues (p. 30). The position of the AAAS (1989) further validates the integration or incorporation of societal issues such as environmental conservation in science education. It is stated that:

Science, energetically pursued, can provide humanity with knowledge of the biophysical environment and of social behavior that it needs to develop effective solutions to its global and local problems; without that knowledge, progress toward a safe world will be unnecessarily handicapped. ... By emphasizing and explaining the dependency of living things on each other and on the physical environment, science fosters the kind of intelligent respect for nature that should inform decisions of recklessly destroying our life-support system. (p. 12)

Steiner (1973) argued that societal issues 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). Similarly, following a survey of Canadian curricula, Wiener (1990) concludes:

Although environmental education has been described as interdisciplinary in nature, cutting across all of the curriculum, the results of this survey seem to suggest that it is strongly associated with and legitimized through the science curriculum and science education. (p. 187)

Significance of societal expectations and socio-cultural context

The preceding analysis attempted to demonstrate some valid perspectives of science and technological literacy which are evident in the national school curriculum of Zimbabwe and that
the conceptions regarding the construct are essentially congruent to what science educators elsewhere around the world expect. In fact the current curriculum is developed and assessed by the Ministry of Education in conjunction with the University of Cambridge Examinations Board in the United Kingdom who, until about 6 or so years ago, provided the science curriculum. On the one hand in Zimbabwe, like in many developing countries, science and technology are interchanged with modernization and national development (Cobern, 1989; Morris, 1983; Nichter, 1984). The current five year national development plan states that "development of science and technology is Zimbabwe's long term and most important strategy for economic and social development" (Government of Zimbabwe, 1991; p. 84). However, this expectation is likely to be frustrated by the lack of widespread scientific and technological literacy among the vast majority of the people and by the lack of a spontaneous utilization of the scientific world-view in ordinary problem situations even among those who have some education in science. In addition to the problem in attainment of science and technological literacy which can be partly attributed to difficulties in conceptualization about what it is and what evidence demonstrates it, in developing countries there is an added difficulty that the scientific world-view is like a second culture as observed by Ogawa (1986) and Ogunniyi (1988). As Cobern (1988) notes, 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 issue of cultural context is also expertly articulated by Morris (1983) who explained that education does not take place in a cultural vacuum and that "it occurs against the background of a view of the world and of humanity's place in it which are characteristics of a particular society" (p. 97). Socio-cultural context is particularly important given that in Africa in particular, modern science is an imported phenomenon and is almost entirely alien to the great majority of people. As Morris (1983) reasons in the context of African countries in general:

This surely means that it [science] must lose its alien character and become rooted in the social milieu whose particular characteristics it must adopt. ... Efficient science teaching must necessarily stress scientific knowledge. But, to be effective, it must take the object of
its study from the local environment, and adapt the explanation of it to the rational ideas that locally exist. In other words, it must become an exercise in participation, making it easier for the taught to grasp the phenomenon and conceptualize it. (p. 54)

In this paper it assumed that science educators need to understand the context in which the business of science education occurs and therefore in as much as teacher knowledge includes understanding of the nature of science and science–related societal issues so it must include knowledge of traditional culture. A review of indigenous culture in Zimbabwe is used to demonstrate its dimensions often over-looked in science education as a precursor to analyzing the research concerning the nature of science, instructional ideology, and socio-cultural variables.

**Indigenous culture of Zimbabwe**

The literature and interview sessions with three lecturers at the University of Zimbabwe revealed a picture of traditional culture which is summarized in this section. While the experts described Zimbabwean culture as multiethnic, multilingual, and multi-cultural they also admitted that the traditional perception of reality or world-view was more pervasive. Western culture is more pronounced in urban centers than in rural areas where at least 80% of the people live according to traditional custom and lifestyles (Chinyakare). Although many Zimbabweans have adopted western material values, Chirungu, they are still closely attached to their moral and spiritual past, Chivanhu. The African indigenous culture is dominated by the customs, beliefs, and values common to Shona and Ndebele ethnic groups who together make up over 90% of the population (Nelson, 1982). Both groups are patrilineal and value an extended family structure in which the living family members and the departed ancestors are in constant interaction in a linear seniority hierarchy. A simplified linear hierarchy, each level has its own sub-hierarchy, can be depicted as ancestors and elders (grand fathers and mothers) at the top, mothers and fathers in the middle,

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1 While every attempt is made to use non-sexist language in this paper, this section contains material which may reflect gender bias. In an attempt to depict the patrilineal and male dominated nature of the traditional culture under study, authors cited will use 'he,' 'man,' 'his' and other male symbolism even when they are referring to both sexes. The situation is changing with legislation and increased access to education.
and children at the bottom. This order of seniority or junior-ship applies on matters of respect, privilege, and wisdom.

Traditional education is based in the belief that social roles should be delineated by gender. Some claim that sex role or gender differentiation is practiced not "to prejudice the child against the other sex, but to let it grow naturally into its predestined role" (Aschwanden, 1982; p. 44). In addition to gender, for each person the functions in the family and in the kinship group are defined also according to age. At particular ages, the pre-specified functions are performed following a fixed code of manners and adhering strictly to the 'correct' procedures laid down by tradition. There is always a strictly enforced correct traditional method or procedure for virtually all activities (Gelfand, 1965). Normal behavior is judged on one's adherence to oral traditions and customs which require respect for the linear seniority hierarchy and subordination to traditional authorities or elders. Gelfand (1965) observes that:

... the spiritual beliefs of the Shona tend to make them conform in behavior and outlook. As their ancestors were good, kind and decent people, so their descendants are expected to follow their example. What is good for the father is good for the children. (p. 124)

Children, junior adults, and females are at the nadir of the seniority and privilege hierarchy and therefore cannot argue, query, or contribute to decision making in the family or community without specifically being asked to do so. It is generally inappropriate and disrespectful for children, junior adults, and females to query authority knowledge or decisions made by elders. Great effort goes into ensuring that children behave well by observing the seniority hierarchy. Aschwanden (1982) claims that "if we ask a Karanga [a Shona subgroup] what he [sic] means by education, his first response will be: to learn to behave well" because without such an education a child would "grow into a human animal, and the parent who does not educate his child properly does the child an injury" (pp. 42–43).

Africans in general are said to be notoriously religious and religion "exerts probably the greatest influence upon the thinking" (Mbiti, 1990; p. 1). Mbiti even asserts that Africans do not know how to exist without religion and therefore:
Wherever the African is, there is his religion: he carries it to the fields where he is sowing seeds or harvesting a new crop; he takes it with him to the beer party or to attend a funeral ceremony; and if he is educated he takes religion with him to the examination room at school or in the university; if he is a politician he takes it to the house of parliament. (p. 2)

A similar situation is apparent in Zimbabwe where an Anglican reverend observed that for every activity among the Ndebele people there is religion; "for example, if you go to the field, you find religion there; if you have a wedding, cattle, a new baby, illness, happiness, death or drought, religion is there" (Bozongwana, 1983; foreword). The works of Aschwanden (1982), Gelfand (1965), and Nelson (1982) demonstrate that the same could have been said about the Shona peoples in general. The traditional world-view is embedded deeply in a religious context as the case elsewhere in Africa (MacGaffey, 1986; Mbiti, 1990). In part because of its religion and faith, traditional culture differs substantially from science in the basic assumptions on which experience and phenomena are interpreted. Interpretations of experiences are deeply personalized, subjective and connected to the quality of people–people and people–spirits relationships (Bourdillon, 1987; Gelfand, 1973). These relationships are featured tremendously in people's perception of causality and causal relationships. Gelfand speculates that the sustenance of social relationships is so vital "with an almost neglect of the material aspects of life" (Gelfand, 1973; p. 198). This implies that sustaining harmonious relationships and avoiding social tensions is considerably more important than understanding relationships between inanimate objects. MacGaffey (1986) speculated on the possibility that preoccupation with sustaining social and spiritual relationships diminishes the potential for Africans to pursue natural science.

A subjective interpretation of experience and phenomena contributes to a perception that everything has an underlying cause and an attitude that virtually everything can be explained. One expert illustrated this point with a Shona proverb which goes *chiripo chariuraya, zizi harifi nemhepo* [there must be something which killed the owl, air cannot kill it] to emphasize that the underlying causes exist (T. Shoko, personal communication, April 25, 1994). This certainty about causes is supported by a attendant readiness to provide cosmological and mystical explanations.
For example, angered spirits, witchcraft or sorcery are the mysterious causes or explanations of experience out of the ordinary (M. Bourdillon, 1987). For this reason, according to Shona belief, western medicine "can only alleviate the symptoms of abnormal illness, or at best it can cure the present illness, but it remains useless against the original cause of an illness which can always strike again" (Bourdillon, 1987; p. 149) and thus sickness and misfortune are believed to have both ordinary physical causes and "true" mystical or spiritual causes. The spiritual explanations are important in that they provide psychological relief (R.B. Batidzirayi, personal communication, April 15, 1994). Mbiti (1990) demonstrates this for Africans in general:

Even if it is explained to a patient that he has a malaria because a mosquito carrying malaria parasites has stung him he will still want to know why that mosquito stung him not another person. The only answer which people find satisfactory to that question is that someone has 'caused' (or 'sent') the mosquito to sting a particular individual, by means of magical manipulations. Suffering, misfortune, disease and accident, are all 'caused' mystically, as far as African peoples are concerned. To combat the misfortune or ailment the cause must also be found, and either counteracted, uprooted or punished. (p. 165)

The relationships of one's family with ancestors as well as the social relationships among human beings in the community provide plausible explanation for misfortune or disease. It is important to note, as Michael Bourdillon explains, that the Shona do accept natural causes of phenomena insofar as these causes can answer how something happens (i.e. the same explanation as in science) but do not accept them to explain why to this particular person and why at this time and place (the mystical explanation). On this basis, accidents or chance occurrences and other unpredictable occurrences are not readily accepted in traditional culture. As an example Bourdillon (1987) cites the case where a man drowns attempting to cross a swollen river. He says of this incident "the natural cause of death was obvious, but his relatives still wanted to know what had blinded him to the danger..." (p. 173) which begs for the mystical explanation. This example demonstrates also that mystical explanations of phenomena work in conjunction with evident natural causes. Oggunniyi (1988) observed similar kinds of reasoning patterns among some Nigerian people and conjectured that the world-views are not necessarily mutually exclusive and therefore it is possible to hold both a scientific as well as a traditional view of the world. Oggunniyi also speculates on the
possibility that the scientific world-view may not be able to completely displace the traditional world-view even after reasonably thorough exposure to science education.

Belief in cosmological causes or mystical explanations is supported and validated via top-down problem solving processes such as divination and revelation. Divination is thought to provide a means to acquire understanding of the nature of the problem and a sure means to provide a psychologically satisfying solution. For example it provides a means to explain observed unusual trends in natural cycles and/or "incomprehensibles" such as outbreak of diseases, drought, pests, and carnivores (T. Shoko, personal communication, April 25, 1994). In this case a spirit medium or diviner is consulted to make contact, receive and communicate messages to and from the spirits enabling people to be given knowledge of things that would otherwise be difficult or impossible to know (Mbiti, 1990; p. 167). According to Kirby (1986) divination "offers the means of knowing what cannot be experienced empirically through the senses or deduced by logic" and therefore increases certainty and predictability about occurrence of life experiences (p. 105). Gelfand (1965) once wrote that the Shona do not like uncertainty and it seems that divination is one way by which uncertainty and doubts are cleared. This contrasts the scientific world-view where, for example, it is asserted that uncertainty mark of all of science (Kimball, 1967). MacGaffey (1986) speculated that diviners or healers may be regarded something like scientists since their role includes attempts to explain some part of experienced reality. This overview is an attempt to show that the premises of the scientific world-view differ from the premises of traditional world-view, yet both represent legitimate ways of interpreting experience (Ogunniyi, 1988; Yakubu, 1994). Dealing with the apparent contradictions should be a concern for science educators working especially in traditional non-western contexts. Figure I delineates some categories representing dimensions of indigenous culture in Zimbabwe.

What this review of the literature established is that the basis on which experiences are perceived and interpreted in indigenous culture is different from the way indigenous students are taught to perceive and interpret the same experiences in science. Traditional culture is sustained by
Dimensions of traditional culture

1. Sex role type education: belief that social roles should be delineated by gender; inequality between sexes; treatment of females as minors; male dominance.

2. Reverence for authority figures: belief that locus of control and wisdom lie with elders; authoritarianism; emphasis on linear seniority hierarchy and subordination; inappropriate to query authority knowledge or decisions; knowledge passed on from ancestors and elders orally.

3. Religious ideology: spirituality based on belief in God, ancestors and spirits as determinants of fortune, misfortune, or other experiences; focus on sustaining normal social and spiritual relationships with kin and spirits; humans at center of universe.

4. Causality and causal attribution: attributing success and failure to human or spiritual agents; belief in mystical or teleological causes of phenomena; 'true' causes as evil forces, witchcraft and magic; not accepting chance occurrences.

5. Procedures for problem solving: adherence to 'traditional' top–down problem–solving procedures; problem solving as a group function; establishing mystical causes or explanation for observed reality via divination; establishing 'true' causes of experience; knowledge not shared or kept a secret.

6. Orientation to social change: preference for living as in the past, Chinyakare; conservative attitudes and strict adherence to traditional values; preference for rural–roots; accepting what life provides or withholds; non–responsibility for outcomes and innovation; normal behavior based on custom and tradition.

7. Family and goal structure: preference for cooperative existence and activity as opposed to individualistic goals; group completion of tasks; group consensus and unanimity in decision making; acceptance of extended family structure or living with kin; family members contributing to well–being of the individual.

8. Relationship with nature: view of nature as sacred and mysterious; attaching human, spiritual and mystical qualities to plants, animals and land forms; taboos and prohibitions related to natural environment; restricting and regulating use of resources; nature as both benevolent and malevolent.

9. Sorcery, magic, and witchcraft: use of magic or charms to enhance skills including farming; ailments or misfortune blamed on people using magic; use of supernatural powers or forces to harm others; paradigm for anti–social behavior.

Figure 1. Some categories of indigenous traditional culture in Zimbabwe

observing oral traditions which are strictly enforced by adult members of society. Normal behavior requires observing and respecting the linear hierarchy in which younger members of the community including females and children are at the nadir and thus have lesser privilege to query, criticize, and contribute to decision making. Questioning authority is often regarded as disrespectful and
children who are inquisitive are chided for doing so, \textit{akangwarisa}. Knowledge and wisdom which already exist in oral tradition are passed from elders to the next generation; problem solving is from top–down, following exact procedures established by tradition. In the top–down hierarchy, elders are supposed to be wiser and more knowledgeable than junior members. Normal social relationships must be sustained and indeed the whole philosophy of traditionalists revolves around the human being (Gelfand, 1973; Bourdillon, 1987). Observations and experiences are typically perceived and interpreted from a personalized and subjective point of view. Typically, upset social or spiritual relationships provide a psychologically satisfying explanation of unusual trends and/or misfortune. Understanding and sustaining harmonious social relationships is thus considerably more important than materialism or preoccupation with understanding relationships among objects. While natural physical causes may be discerned, causal attribution is based on belief in spirits or their agents and thus cosmological reasoning dominates thinking about causes. This leaves relatively little room for experimentation. In addition, this creates a situation where chance occurrence and probability are not tolerable and where therefore certainty and predictability are preferred.

These issues are raised because Zimbabwean society is predominantly traditional (Nelson, 1982). These observations and issues define the indigenous world-view which represents the way reality is experienced, interpreted, and perceived. It was therefore expected that indigenous science teachers would have some inclination to indigenous cultural values and beliefs and that this orientation would have an inverse relationship to their perception of the nature of science, societal issues, and instructional ideology which are themselves expected to be correlated positively.

\textbf{Nature of science studies}

Research conducted mainly in the West gives the basis to assume a direct positive relationship among understanding of the nature of science, instructional ideology, and understanding of science–related societal issues and their negative relationship with traditional world–views. In this section, research on nature of science is described briefly since the results of
major reviews have been reported (Blakely, 1987; Meichtry, 1993; Lederman, 1992). These reviews demonstrate that in the past half century, studies on the nature of science were descriptive and aimed at finding out the conceptions students and teachers held on several models of the nature of science. A frequent conclusion was that their conception was inadequate and in some cases curriculum and instruction which was deliberately designed to effect an understanding of the nature of science produced some discernible improvement. The commonest problem was that teachers tended to view science as a fixed body of knowledge and failed to perceive scientific findings as tentative, a finding which is continuing to be reported (Bloom, 1989; Aguirre, Haggerty, & Linder, 1990).

A few studies in the USA and in Israel (Lederman, 1992) found no correlation between the nature of science scores and academic and professional variables such as college science courses taken, college or science grade point average, length of teaching experience, science subjects taught, and undergraduate major. These findings raise the possibility that socio-cultural context variables may account for nature of science scores. Bloom (1989) working with elementary science teachers found that they perceived that the primary purpose of science was to benefit humankind and demonstrated a lack of understanding of the role of scientific theory. Their anthropocentric beliefs significantly influenced their concept of nature of science as well as their view about how it should be taught. It can therefore be speculated that with a culture, such as that in Zimbabwe, where humans are philosophically believed to be at the center of the universe, an anthropocentric view of the nature of science is likely. Bloom (1989) also demonstrated a link between views of the nature of science and instructional preferences; this appears to be corroborated by Aguirre, et al, (1990) who using open-ended questions found that teachers were evenly divided between "dispenser of knowledge" and "guide or mediator" instructional viewpoints. Teachers were equally distributed between those oriented to traditional and to contemporary notions of science teaching respectively. Aguirre, et al, (1990) concluded that there was some kind of relationship between teachers views on the nature of science and their conceptions of teaching and learning.
An important point to emerge from the review is that while the samples studied were mostly from western cultures which are supposed to be closer to science in terms of compatibility of their world-views, teachers there held authoritarian views concerning the nature of science and instructional ideology. Further, there is lack of relationship between academic variables and teaching experience and nature of science views held leading to the possibility that other situational variables mediate perspectives acquired concerning the nature of science and instructional ideology. Socio-cultural environment variables and commitment to a traditional cultural world-view might have some connection to conceptions of the nature of science and its relationship to technology and society and instructional ideology. The importance of socio-cultural contexts and indigenous world-view in science education can be extrapolated from the results of predominantly western studies on instructional ideology.

**Instructional ideology studies**

As pointed out in a preceding section, nature of science studies assume a direct positive relationship between teacher instructional behaviors and classroom environment hence student understanding of the nature of science (Lederman, 1986a, 1986b, & 1992; Meichtry, 1992 & 1993). Tamir (1983) and Hodson (1988), for example, postulated that understanding the nature of science is related to teachers' ability to distinguish between teaching science as inquiry or by inquiry. Chiapetta, Sethna, and Fillman (1991) reported that teachers with weak or lack of understanding of the nature of science fail to develop science ideas and concepts which they teach around "the models that scientists used to form these concepts" (p. 940). This resulted in superficial and parsimonious treatment of both subject matter and the nature of science. Chiapetta, et al. (1991) also found that teachers lacking adequate understanding of the nature of science typically had greater dependence on texts, traditional instructional methods, greater concern with maintaining discipline and control, and other non-science task related concerns. They therefore failed to present science as a humane enterprise involving knowledge, investigation, thinking, and technology as well as the impact of science and technology on society.
The preceding overview of traditional culture suggested that people growing in it may be authoritarian and perhaps even closed-minded. If that assumption is correct, then the results of some western studies in particular those of Jones and Harty (1978), Symington and Fensham (1976), and Lazarowitz (1973) can be extrapolated to the present context. They examined teachers' instructional ideology and their dogmatism as measured on the Rokeach (1960) dogmatic scale. Teachers who had a preference for inquiry were more humanistic (Jones & Harty, 1978). Symington and Fensham (1976) found that closed-minded science elementary teachers preferred obedient, quiet, reserved pupils who liked to work alone and who readily accepted judgment of authorities. Teachers' orientation toward inquiry and attitudes towards science as implied in curriculum materials was found to be negatively correlated to dogmatic scores. Teachers scoring high on dogmatic scales were more traditional in their beliefs about their classroom behavior and they exhibited less inquiry behaviors. Strawitz (1977) found that teachers who were less dogmatic were more likely to acquire attitudes and behaviors consonant with the philosophy of new science curricula. It is conjectured that these findings may be related also to culture-of-origin beliefs whereby an authoritarian orientation of a culture could serve to influence teachers to have beliefs less inclined to inquiry teaching behaviors and thus provided some theoretical support for the conjecture developed in this article.

Theoretical and practical significance of socio-cultural and world-view research

Although Cobern (1989) noted that science is the same wherever it is found, it appears that it is important to consider the socio-cultural context in which it occurs. Societal expectations have a potential to influence conceptions of the nature of science. For example, Odhiambo (1968), Morris (1983), Chisman (1984), and Nichter (1984) note that Africans, especially political leaders, perceive science in terms of aspects related to industrial production of goods and application of existing scientific knowledge to industrial processing. In Zimbabwe a perception is created that science and technology can and should be concerned with practical applications and with production of useful technology. Cobern (1989) himself speculated that this societal expectation
when based on an inadequate view of the nature of science can lead to general disillusionment and rejection of science when it fails to deliver the goods. Odhiambo (1968) noted that there is 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 solving situations. Numerous researchers have also noted 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; Gelfand, 1973). However, as Yakubu (1994) notes:

this should not be construed to suggest that science and technology are incomprehensible to people in the developing countries. The suggestion is that spontaneous application of the scientific spirit learnt through the western form of education is lacking. There seem to be something which inhibits the spontaneous application of scientific ideas in problem situations. 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)

This quote illustrates the fact that traditional world-view is different from the scientific world view to be developed in science education. The American Heritage (1992) defines world-view as the "overall perspective from which one sees and interprets the world" and also as "a collection of beliefs about life and the universe held by an individual or a group" (p. 2058). From the perspective of world-view theory, it seems that science education for a long time has been based on the "cultural assimilation" model whose assumptions appear untenable (Barba, 1993). This model assumes that students can simply assimilate the scientific world-view to supplant the world-view they acquired in their culture-of-origin. In non-western societies, it is now increasingly accepted that understanding the contribution of a traditional world-view to science learning or to the adoption of a scientific world-view is a significant endeavor (Ogawa, 1986; Ogunniyi, 1988).

Further significance of studying socio-cultural contexts can be drawn from a recitation of experiences of westerners when they have taught in Africa. For example, Shrigley (1983) recalled and described his experience in a teachers' college in Nigeria as follows:
Teaching science in a developing country, I found students who were seeking simple answers to complex scientific phenomena, distressed by the tentative nature of the scientific enterprise. There was a tendency to embrace, even tongue-in-cheek, information having a superstitious base, but at least a definite answer, in preference to wrestling with several scientific alternatives. To illustrate the frustration that the lack of sure and fixed knowledge can generate, one student made a public appeal that I teach only what scientists were sure of! (p. 427)

This quote highlights the influence of an authoritarian world-view where knowledge is not considered tentative and consequently many statements have been made exhorting science educators to modify or supplant indigenous world-view with the western science. For example Odhiambo (1968) once stated that "the African must be saved (sic) from living two worlds— one of belief, and the other of natural science" (p. 45). It does seem that this cannot be done via the assimilation model.

The preceding citations illustrated that for attainment of a reasonable level of scientific literacy reference to the cultural referents of the learner or for that matter those of the "indigenous" teacher is necessary. They also reflected an inherent problem in trying to supplant the African traditional world-view with the scientific world-view. A more tenable approach can be deduced from constructivist theory (Cobern, 1991 & 1993; Ogawa, 1986; Ogunniyi, 1988). This theory endorses that cultural backgrounds of students provide them with prior knowledge and experiences which influence their acquisition of new forms of knowledge. This is what Jegede and Okebukola (1991a) were illustrating when they wrote:

Indeed, since every society educates the young generation as a means of passing down the socio-cultural attributes of its people, the socio-cultural factors within non-western societies become a composite part of the environment and therefore control to a very large extent what a child in such an environment learns and becomes in later life. (p. 276)

A cultural accommodation model proposed by Ogawa (1986) and extended by Ogunniyi (1988) is more consonant with constructivist learning and the need to take into account cultural knowledge. Ogawa's (1986) model articulates that western science and traditional culture are in conflict because they differ in their world-view. Adapting and extending this model, Ogunniyi (1988) elaborates that when views of nature and ways of thinking are un-resolvable, they lead to rejection
of science and reversion to one's indigenous world-view. On the other hand when the conflicts can be resolved this can lead to accommodation of the scientific world-view. Ogawa (1986) proposed that science should be seen within the context of the students' indigenous culture. On the same point, Ogunniyi (1988) asserted:

It seems that if the scientific world view is to succeed in Africa and perhaps other traditional societies, the aim should be geared towards accommodation rather than assimilation. The African should not be presented science from a superior vantage point but as a way he can cope better with certain experience. ... The aim of science education I am proposing here should not be to supplant or denigrate a traditional culture but to help people meet modern challenges. (p. 8)

These observations suggest that the indigenous world-view in non-western culture is different from the scientific world-view but at the same time they raise hope in the potential of their integration. However, Ogunniyi (1988) reports that the traditional world view of literate and non-literate people living in traditional society in Nigeria is not totally devoid of scientifically valid views of the universe.

The implications of an indigenous world-view is expected to be far reaching (McKinley, Waiti, & Bell, 1992; Prophet, 1990). As the research cited demonstrates, it is likely to impact the learning behaviors of students and teachers as well as their perception of scientific knowledge. For example, it is possible that indigenous world-view influenced Zimbabwean primary school students to prefer to watch the teacher (an authority figure and know all) to make science "demonstrations" rather than them participating hands-on (Lewin & Bajah, 1991). For example, in Nigeria, in a recent study of pre-degree science students, Jegede and Okebukola (1991b) found that indigenous world-view is implicated in the way students observe, perceive, and interpret experiences. They concluded:

... 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 high level of belief. ... it does seem that African traditional beliefs exerted the most influence on observational tasks in comparison with gender and religious affiliations. (p. 43)
Implications for science education research

Personal experience and experience of others like Aschwanden (1982), Nelson (1982), Bourdillon (1987), Gelfand (1973), and Bozongwana (1983), to name a few, demonstrate that a scientific perception of reality is not part of the everyday cognitive and affective repertoire of many people in Zimbabwe. Mbiti (1990), writing about Africans in general, asserted that:

Every African who has grown up in traditional environment will, no doubt, know something about this mystical power which often is experienced or manifests itself, in form of magic, divination, witchcraft and mysterious phenomena that seem to defy immediate scientific explanations. (p. 189)

This assertion demonstrates the existence of different world-view in which it is believed, unlike in science, that every experience can and must be explained satisfactorily. Explanations go beyond the immediate physical or natural contingencies in traditional culture as apparent in Aschwanden (1982) conclusions about a subgroup of the Shona. He remarked that "the Karanga cannot conceive of the idea of disease or illness without, at the same time, taking into account such aspects as belief in God, ancestral spirits, man's relationship with nature, problems of marriage and of sexual intercourse, and many others" (p. xiv). Nelson (1982) notes the preoccupation of indigenous Zimbabweans "with this world and with the effects of the spirits on the welfare of the living" (p. 118) and that in the world-view of Zimbabweans "there is little room for chance or of the notion that microorganisms or weather systems indifferent to human beings inadvertently affect their welfare" (p. 119). A Zimbabwean may, for example, make use of modern medicine because it relieves the symptoms but may still be concerned to know why an illness was inflicted upon him. It is expected therefore that indigenous teachers' understanding of the nature of science, environmental conservation, and instructional ideology are influenced by the attitude-value complex or world-view they acquired in indigenous culture or by the degree to which their beliefs were oriented towards indigenous culture. As noted in this article and by other researchers in comparable cultural contexts, the problem might lie in "indigenous cultural behavioral and thought patterns" (Yakubu, 1994; p. 344) which were different than in science.
Given these observations and background developed in preceding sections of this article, a particularly stimulating line of research appears to be the examination of how indigenous science teachers' socio-cultural backgrounds and orientation to indigenous cultural beliefs and values are connected to their conceptions of the nature of science, instructional ideology, and science and technology related societal issues. Preceding sections of this article attempted to address the nature of traditional culture and world-view relative to the nature of science and demonstrated areas of dissonance. It remains to identify whether or not science teachers have a commitment or not to indigenous cultural beliefs and values and what connection those beliefs have with their conception of the nature of science, science and technology related societal issues, and instructional ideology. Given that indigenous teachers are confronted on a day-to-day basis by contradictions between their own world-view and the scientific world-view as well as between the scientific world-view and their students' world-view, it is also imperative to understand what they perceive as the nature of interaction of indigenous culture with science education. There is need for action educational research to help teachers deal more effectively with issues raised in this article as well as theoretical studies which articulate the casual models by which various socio-cultural environment factors and indigenous belief and thought mediate acquisition and adoption of the scientific world-view. Methodologically these problems call for a judicious mix of quantitative (surveys and observations) and qualitative (interviews and cases studies) research techniques.

The author has embarked on this enticing line of research by carrying out a status determination study with a sample of science teachers on the Bachelor of Education program. In that study the speculated inverse relationship between science teachers' commitment or orientation to traditional cultural beliefs and values and their perceptions concerning the nature of science and scientific knowledge, science and technology related societal issues, and instructional ideology is tested. In addition, open-ended data were collected to evaluate the science teachers' experiences and examples of interaction of indigenous culture with science education. This promising line of
research should continue to gain impetus in the future and hopefully more people will adopt a scientific world-view than is currently the case.

References


CHAPTER III. RESEARCH DESIGN AND METHODOLOGY

Introduction

The purpose of the study was to explore relationships among science teachers' orientation to traditional culture and their conceptions and awareness regarding instructional ideology, the nature of science, and a science and technology related societal issue, environmental conservation. It also sought to describe their academic, professional, family, and socio-cultural backgrounds and how these variables were related or explained differences in their perceptions. The methodology selected to address the research questions was the questionnaire survey technique (Borg & Gall, 1989; Ary, et al., 1990) and the focus group interview technique (Krueger, 1988). The survey method was selected since no treatment variables were manipulated and since non-causal relationships were explored. The focus group technique permitted the researcher to gain insight into the teachers' perceptions regarding the qualitative interaction of traditional culture and science education. This chapter summarizes the research design and the procedures used in gathering data for the study. This research was reviewed and approved by the Iowa State University Human Subjects Review Committee (HSRC).

Null hypotheses

The broad problem investigated in this study is summed up in the following question.

What are the relationships among indigenous Zimbabwean secondary science teachers' perceptions on the nature of science, societal issues, science instructional ideology, their socio-cultural backgrounds, and their orientation to indigenous cultural beliefs?

A negative relationship was expected between science teachers' scores on the nature of science, societal issues, and instructional ideology and scores representing the level of orientation toward indigenous culture values and beliefs. The rationale for this conjecture was developed in Chapter I and in Chapter II. The hypotheses to all the research questions except 1, 2, and 5 (Chapter I) are stated in the null form, an essential step in the process of testing for statistical significance.
No specific hypotheses were developed for Question 1, 2, and 5 which were addressed qualitatively.

The null hypothesis states that there is no relationship or that there is no difference between variables to be compared (Hinkle, et al., 1988; Ary, et al., 1990). Testing for statistical significance therefore involves finding out the probability that observed relationships or differences are larger than those created by chance or random errors. The process permits the researcher to assess how significantly different the relationship or difference is from that predicted in the null hypothesis at a given level of significance or alpha. In this study the level of significance was established at .05 prior to data analysis and hypothesis testing.

H₀1. BEd science teachers will have neither high nor low orientation toward African indigenous culture when measured on a researcher developed orientation to indigenous culture scale.

H₀2. BEd science teachers will have neither adequate nor inadequate understanding of the nature of science scores when measured on Kimball (1967) and on the Rubba-Andersen (1978) scales.

H₀3. BEd science teachers' scores on the nature of science and on the nature of scientific knowledge will be equal to scores of American and Nigerian science teachers.

H₀4. BEd science teachers will have neither a negative nor a positive awareness of a societal issue, environmental conservation.

H₀5. BEd science teachers will show equal preference for inquiry and for traditional instructional ideology when measured on the Jones–Harty (1978) ideological preference scale.

H₀6. There will be no relationship between BEd science teachers' orientation to their indigenous culture score and their inquiry instructional ideology preference, their environmental conservation awareness, and their understanding of the nature of science scores.

H₀7. There will be no relationship between BEd science teachers' instructional preferences and their environmental conservation awareness and their understanding of the nature of science scores.

H₀8. There will be no relationship between BEd science teachers' understanding of the nature of science scores and their environmental conservation awareness scores.

H₀9. There will be no differences in BEd science teachers' (i) orientation to indigenous culture, (ii) instructional ideology, (iii) environmental conservation awareness, and (iv) understanding of the nature of science when the BEd science teachers are grouped according to personal, academic, professional, and socio-cultural characteristics.
Figure 1 shows the chapters in which the results of addressing or testing each research question or hypothesis are presented. Some of the questions and hypotheses are addressed in several chapters due to the emphasis placed in exploring the interrelationships among constructs and socio-cultural variables in the study.

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<tr>
<td>Chapter II: Review of the literature</td>
<td>Review and theorized connections among all variables and constructs plus Q2 and Q5</td>
</tr>
<tr>
<td>Chapter III: Methodology</td>
<td>Q1 and general summary of sample characteristics</td>
</tr>
<tr>
<td>Chapter IV: Interaction of indigenous culture and science education</td>
<td>Q1, Q2, Q3, and Q5</td>
</tr>
<tr>
<td>Chapter V: Orientation to indigenous culture and instructional ideology</td>
<td>Q1, Q2, Q4, Q5, Q9, and Q10; H01, H05, H06, and H07</td>
</tr>
<tr>
<td>Chapter VI: Conception of the nature of science and scientific knowledge</td>
<td>Q1, Q6, Q7, Q10, and Q11; H02, H03, H06, H08, and H09</td>
</tr>
<tr>
<td>Chapter VII: Awareness of societal issues</td>
<td>Q1, Q8, and Q10; H04, H06, and H08</td>
</tr>
<tr>
<td>Chapter VIII: Summary and discussion</td>
<td>Results on all Qs and all H0 summarized and discussed</td>
</tr>
<tr>
<td>Appendix</td>
<td>Supplementary data tables H01, H02, and H03</td>
</tr>
</tbody>
</table>

Figure 1. Summary of the dissertation chapters and the research questions and hypotheses addressed or tested.

Sample

The study used a sample consisting of all 66 science teachers who were enrolled in the Bachelor of Education degree program at the University of Zimbabwe. These teachers had successfully completed Part I and were now in Part II of the two year degree program. The 66 science teachers were distributed unequally among chemistry (21), physics (27), and biology (18)
specialties. The final sample was comprised of 63 BEd science teachers because 3 did not complete and return the questionnaire after two follow-up reminders. Of this sample, 58 provided written responses to an open-ended question. Approximately 20% of the sample was randomly selected and invited to participate in a focus group interview session.

Besides being accessible to the researcher, the BEd science teachers were considered appropriate for the study because teachers in this program were being prepared for major teaching and curriculum development responsibilities in Zimbabwe’s education system. Science teachers enrolled in the BEd program are expected upon completion to teach their subject to all levels of the secondary school system, to participate effectively in curriculum development, to teach in the teachers’ colleges, and to service other divisions of the Ministries of Education (University of Zimbabwe, 1994). The sample also consisted of science teachers who were already certified to teach secondary school level science and who were undergoing in-service training in order to upgrade both their subject and pedagogical knowledge and skills to degree level. Upon completion these teachers were most likely to have great impact on the secondary science curriculum and the way it is implemented. All of the teachers were indigenous Zimbabweans who were expected to be capable of articulating their experiences and perception concerning the interaction of indigenous culture and science instruction. They could base their perceptions on either their own experiences as students and as teachers of science or on their observations of the hundreds of students they had taught science in secondary schools.

The BEd program history and structure

The BEd curriculum is such that 85% consisted of content in the teaching subject, science, and 15% is in science curriculum theory and in A level methods of teaching. Recommendations arising from the study are most directly applicable to these two professional components, science curriculum theory and methods of science teaching, of the BEd program. Ensuring that teachers develop an understanding of the nature of science is said to be a domain of methods or science education courses (Akindehin, 1988; Blakely, 1987). It is essential to give some background to the BEd program.
The Bachelor of Education program, alternatively recognized as the Zimbabwe Science Teacher Training Project (ZIMSTT), is administered by the Department of Science and Mathematics Education in the Faculty of Education in corroboration with the Faculty of Science. It is funded through the Netherlands Organization of International Cooperation in Higher Education (NUFFIC). Implementation of the ZIMSTT project began in 1986 when biology and physics students were admitted. A year later, the chemistry and mathematics options were introduced. The degree programs in mathematics, physics, chemistry or biology education are two year full-time programs designed to prepare secondary school teachers for responsibilities in teaching, curriculum development, and teacher education (University of Zimbabwe, 1994).

The program admits applicants who have undergone training for the profession of teaching, have completed at least two years of approved post-training educational work, and have at least one Advanced Level (approximately grade 13) pass in the proposed science teaching subject (either biology, chemistry, or physics). Geography and mathematics majors were excluded from this study. The BEd program consists of one course (a course is defined as 60 contact hours) in the subject pre-requisites to serve as a foundation for the major subject; six courses in the teaching subject itself; a research project or equivalent in the teaching subject representing a time commitment of not less than a single course; and two courses in a professional area associated with the teaching subject (University of Zimbabwe, 1994).

Biology Prerequisites ESMB 101 consisted of chemistry and statistics, Chemistry Prerequisites ESMC 101 consisted of physics and statistics, and Physics Prerequisites ESMP 101 consisted of mathematics and computing. The two professional preparation courses were Science Curriculum Theory (ESME 101) and Science A Level Methods Part I (ESME 102) and Part II (ESME 202) (University of Zimbabwe, 1994; p. 349). Recommendations arising from this study are especially relevant to the science curriculum theory and to the science methods courses. In the first year of the BEd program each student pursued three courses in the teaching science subject and one and half courses in the professional area, science education. At the time of data collection, the BEd
teachers had just begun Part II where they were due to take four science content courses and a research project course (EC3R 370).

Data collection procedures

All research questions except the research questions "what kind of socio-cultural environment constitutes indigenous culture in Zimbabwe?" and "what are the implications of indigenous world-view to science education?" were answered using the questionnaire survey technique. All null hypotheses except H02 were tested and evaluated almost entirely based on the data collected by the questionnaire method. H02 stated that "science teachers will perceive indigenous culture as having a negative influence on the indigenous students' perception and acquisition of scientific knowledge and processes". This hypothesis was assessed qualitatively based on the results of a structured text analysis (Tesch, 1990) on the written question and on the focus group interview open-ended responses.

Survey questionnaire

The primary data collection instruments were the questionnaire and the semi-structured interview protocol. The questionnaire booklet was a compilation of scales measuring the nature of science, instructional ideology, environmental conservation awareness, and orientation to indigenous culture as well as socio-cultural characteristics. Various scales are presented together with data in Chapter V, Chapter VI, Chapter VII, and in the Appendix. The last item in the questionnaire was an open-ended question which sought the teachers' views concerning the interaction of indigenous culture and science education; of the 63 who returned completed questionnaires 58 (92.06%) provided open-ended responses ranging from a single sentence to one and half double spaced pages. Questionnaires were distributed to intact classes in person by the researcher to be completed and returned one week later. On the day the questionnaires were distributed, the researcher explained the purpose and significance of the study, assured confidentiality, and requested cooperation by emphasizing the importance of participation as suggested in the literature (Borg & Call, 1989; Ary, et al., 1990). Similar information was
contained in the letter of transmittal. A four color pen was given as an incentive for participation in the survey.

**Focus group interview**

In order to probe the perceptions of science teachers on the nature of interaction of indigenous culture and science instruction further, a focus group (FG) technique as described by Krueger (1988) was used. This technique provided the qualitative triangulation data for the teachers' orientation to indigenous culture and their perception of the interaction of indigenous culture and science education. According to Krueger (1988)

Focus groups can be used at the same time as quantitative procedures. ... to address the same issue in order to confirm findings and to obtain both breadth and depth of information. Focus groups can follow quantitative procedures. Questionnaires typically yield a sizable amount of data, and focused interviews provide insights about the meaning and interpretation of the results. In addition the follow-up focus groups can suggest action strategies for problems addressed in the questionnaire. (p. 40)

Krueger goes on to say that in addition to low cost, speedy results, and flexibility, the focus group interview technique is a socially oriented research method capturing real-life data in a social environment, and typically, focus groups have high face validity, which is due in large part to the believability of comments from participants. He says, "people open up in focus groups and share insights that may not be available from individual interviews, questionnaires, or other data sources" (Krueger, 1988; p. 42). In this study 14 science teachers representing about 20% of all participants were randomly selected from among the three BEd science majors and invited to participate in the focus group interview session. This interview proceeded following a pre-planned questioning route which allowed for probing depending on the responses of the participants as described more fully in Chapter IV.

**Science teachers' academic data**

It was necessary to establish the academic standing of the science teachers in their current degree program as well as their academic standing in the non-graduate teacher preparatory program in the teachers' college. In order to access and use their academic performance record, BEd
science teachers were requested to read, complete, and sign an informed consent and academic record release form which outlined the purpose of the study, the need for the academic record, and assuring confidentiality. All 66 BEd teachers signed the consent form to give their permission for their academic data to be used in this study. The college and university academic records were accessed in the Department of Teacher Education which accredited the teachers' colleges and in the Department of Science and Mathematics Education where students were currently enrolled respectively. The college records of 8 students could not be located or were incomplete. These data were used to describe the academic performance of the students and how they related to their perception on the constructs of the study.

Data analysis procedures

This section summarizes the procedures used in data analysis. The procedures were selected on the basis of the nature of data collected and on the basis of the research questions and hypotheses to be answered or tested. In order to estimate whether relationships or differences between variables were significant, the level of significance was set at .05. This level of significance is generally applied in educational studies and represents a reasonably conservative estimate of Type I error (Hinkle, et al., 1988). In this study, the statistical levels of significance generated by the StatView II computer program are also reported. Details for each procedure used are contained in the relevant chapters reporting on the findings. Descriptive statistics such as frequencies and percentages were used to analyze and report the demographic information concerning academic, professional, and social backgrounds of respondents. Reliability of the survey scales was estimated by the Spearman–Brown internal consistency procedure (Borg & Gall, 1989); the results of these analyses are presented in this chapter.

Correlations were computer generated and analyzed in order to estimate and assess the magnitude and direction of relationships among science teachers' beliefs and perceptions on the various constructs of the study. Testing correlations involved testing whether they were significantly different than 0. Percentages, scale means scores, and standard deviations were used
to describe the science teachers' beliefs and perceptions to the various constructs of the study. In order to estimate deviation of scores from the neutral or uncertain score t-tests were used. Deviation from neutral was used to assess adequate or inadequate perception of constructs as proposed by Lederman (1986).

The analysis of variance technique (ANOVA) was used to explore differences that may exist in the science teachers' perceptions based on differences among levels of factors such as area of specialization, sex, teaching experience, academic and professional qualifications, and the socio-cultural variables. ANOVA techniques are used when it is desired to assess differences on a dependent measure between levels of different factors and to explore interactions between independent variables (Hinkle, et al., 1988; Ary, et al., 1990; Borg & Gall, 1989). The Scheffe F-test of significance was selected for post hoc analysis to detect sources of significant differences. The Scheffe test was selected because it is a more conservative measure and thus more likely to detect true differences (Hinkle, et al., 1988) between the subgroups within the sample of BEd science teachers. The written open ended responses and the transcript of the focus group interview were analyzed via a structured content analysis technique using pre-specified categories (Tesch, 1990). This qualitative analysis led to the description of the perceived interaction of indigenous culture with science education as elaborated in Chapter IV.

**Reliability of scales**

Only a summary of the scales' reliability is given here; details of validity and reliability are given in the appropriate papers when the results are presented. Reliability was defined in the study as the level of internal consistency of the individual subscales comprising the questionnaire used to gather data for the study. According to Borg and Gall (1989) the reliability coefficient reflects the extent to which a measure is free of error variance. The internal consistency procedure selected was the split-half method. This procedure is used following administration of a scale or test whereby it is split into two halves. The two scores obtained on the two equivalent halves are used to compute a coefficient of correlation, the split-half reliability coefficient. The items for
each scale in the study were randomly distributed; so it was appropriate to correlate the odd-numbered items of a scale with scores on the even-numbered items to obtain an odd-even split-half coefficient of reliability.

However, the split-half procedure yields a measure of reliability for half the scale and therefore underestimates the scale reliability. The Spearman–Brown prophecy formula was employed to obtain the estimate of reliability for the entire scale. The Spearman–Brown prophecy formula is \( R = \frac{2r}{1 + r} \), where \( R \) is the reliability for the entire test and \( r \) is the reliability for half the test. This split-half measure of reliability was selected partly because of its ability to be determined following a single administration of a single form of a measure as was done in this study (Borg & Gall, 1989; Ary, et al., 1990). Additionally, Ary and colleagues (1990) claim that "the method requires only one form of a test, there is no time lag involved, and the same physical and mental influences will be operating on the subjects as they take the two sections (halves)" (p. 276).

Table 1 shows the split-half reliability coefficients of the scales which comprised the questionnaire used in data gathering. For each one of the subscales the split-half reliability coefficient after the Spearman–Brown correction are reported. Reliability of the individual subscales are discussed in detail when data pertinent to teachers’ responses on that subscale are presented. For this sample the least reliable was the Jones–Harty science teachers instructional preferences scale (STIPS) (Spearman–Brown = .37) followed by Kimball’s nature of science scale (NOSS) (Spearman Brown = .40). These two scales were the shortest leading to the possibility that the lower number of items depressed the reliability. Longer scales, i.e., those consisting of more items typically yield higher reliability than shorter ones (Borg & Gall, 1989). The researcher–developed orientation to indigenous culture scale (OICS) and the researcher–adapted environmental conservation awareness scale (ECAS) produced the highest internal consistency. These scales were adapted to the reality and context of Zimbabwe and thus they may have been more culturally syntonic. The reliability of NOSS (.40), the NSKS (.62), and the STIPS (.37) were notably lower than that reported in previous
Table 1. Split-half internal consistency coefficients of scales used in the study

<table>
<thead>
<tr>
<th>Survey Scale</th>
<th>Reliability coefficient&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indigenous culture scale (OICS)</td>
<td>.83</td>
</tr>
<tr>
<td>2. Environmental conservation scale (ECAS)</td>
<td>.66</td>
</tr>
<tr>
<td>3. Teachers instructional preferences (STIPS)</td>
<td>.37</td>
</tr>
<tr>
<td>4. Nature of science scale (NOSS)</td>
<td>.40</td>
</tr>
<tr>
<td>5. Scientific knowledge scale (NSKS)</td>
<td>.62</td>
</tr>
</tbody>
</table>

<sup>a</sup> Internal consistency coefficient after applying the Spearman-Brown prophecy formula.

studies. Kimball (1967) reported for the NOSS a reliability of .72 applying the Spearman-Brown formula, Cobern (1989) reported a reliability of .71 applying the Kuder-Richardson-20, and Andersen, et al. (1986) reported an internal consistency alpha of .74 for the NOSS. For the NSKS Rubba and Andersen (1978) reported reliability ranging from .65 with grade nine general science students to .88 with philosophy of science majors while Mikael (1986) a few years back obtained a test–retest reliability of .92 for the same. Jones and Harty (1978) reported for the STIPS that the inquiry subscale had a reliability of .73 (compared to .54 in the present study) and .79 for the traditional subscale (compared to .59 in the present study).

In order to estimate the inter-rater reliability of coding of open ended response text, an index of agreement $\pi$ was computed (Scott, 1955; Scott & Wertheimer, 1962). $\pi$ is a statistic which represents the extent to which two independent content analysts agree beyond the level that would be expected by chance. It is the appropriate indicator of reliability when two analysts code text on a nominal scale such as the case when they either agree or disagree. $\pi$ corrects for chance "agreement" which often elevates the observed percentage agreement when only a few of the categories are used with appreciable frequency.
Sample demographics

Details on the findings of the study are given in Chapters IV, V, VII, and VIII. These chapters are self-contained manuscripts submitted or ready to be submitted to science education journals. However in this chapter, it is necessary to provide the background to the characteristics of the sample under study; in the individual papers following this chapter, these characteristics will only be presented in summary form as expected when publishing in the limited space of scholarly journals.

Academic specialization, gender and age of science teachers

All of the teachers were indigenous African Zimbabweans. Table 2 gives the distribution of respondents according to the subject of specialization, their gender and age groups. Their distribution according to specialization was as follows: biology (28.57%), physics (41.27%), and chemistry (30.16%). It was established that the higher number of teachers in physics is a deliberate effort to increase the number of A level physics teachers. There was a greater shortage of physics teachers compared to either biology or chemistry teachers. The BEd science program comprised of nearly all male teachers (87.30%). Only nine females were in the program of which only eight responded to the questionnaire. The low number of females in this program reflected on the number of females who had good passes in pre-service teacher training. Applications simply are not being received from female science teachers. Over 95% of all the science teachers were 35 years of age or younger. A majority (41) were in the 26-30 age bracket and only three teachers were 31 years old or older.

Qualifications and teaching experience of science teachers

Table 3 shows the science teachers' academic and professional qualifications plus their post-certification experience. As expected for a youthful group (Table 2), the teaching experience was less than ten years for the majority; more than 95% had 9 or fewer years teaching experience. Twenty eight (44.44%) had 13 years teaching experience and 26 (41.27%) had between 4 and 6 years of teaching experience. Table 3 shows that the majority (63.49%) had advanced level academic
Table 2. BEd science teachers' gender, age groups and area of academic specialization (N = 63)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of specialization in BEd program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>18</td>
<td>28.57</td>
</tr>
<tr>
<td>Chemistry</td>
<td>19</td>
<td>30.16</td>
</tr>
<tr>
<td>Physics</td>
<td>26</td>
<td>41.27</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>12.70</td>
</tr>
<tr>
<td>Male</td>
<td>55</td>
<td>87.30</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–25 years</td>
<td>3</td>
<td>4.76</td>
</tr>
<tr>
<td>26–30 years</td>
<td>41</td>
<td>65.08</td>
</tr>
<tr>
<td>31–35 years</td>
<td>16</td>
<td>25.39</td>
</tr>
<tr>
<td>36–40 years</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td>41–45 years</td>
<td>2</td>
<td>3.17</td>
</tr>
<tr>
<td>46 years and more</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

qualifications in at least one of the sciences or mathematics. Given the fact that there is no kindergarten, Advanced level is comparable to grade 13 on the 7–4–2 system of education, i.e., 7 years primary, 4 years basic secondary (junior and ordinary level), and 2 years advanced level. Twenty three had O level qualifications. Current university regulations stipulated that entry into the program requires at least "5 O levels or their equivalent including English language, the proposed teaching subject(s), and mathematics (if the proposed teaching subject is a science subject)" (University of Zimbabwe, 1994; p. 336). All of the science teachers except 3 had a certificate in education (CE). The certificate in education is a non-graduate professional qualification; in order to earn a BEd degree a CE holder needs another two years at the university. More than half had trained on the post-O level programs. Of these, 14.28% had undergone training for a duration of three years and 58.73% were trained on the four year mode. Only seventeen (26.98%) had trained
Table 3.  BEd science teachers' academic and professional qualifications, and teaching experience (N = 63)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highest academic level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O level</td>
<td>23</td>
<td>36.51</td>
</tr>
<tr>
<td>A level</td>
<td>40</td>
<td>63.49</td>
</tr>
<tr>
<td><strong>Professional qualification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2</td>
<td>3.17</td>
</tr>
<tr>
<td>CE</td>
<td>60</td>
<td>95.24</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td><strong>Training program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 year, post O level</td>
<td>9</td>
<td>14.28</td>
</tr>
<tr>
<td>4 year, post O level</td>
<td>37</td>
<td>58.73</td>
</tr>
<tr>
<td>2 year, post A level</td>
<td>17</td>
<td>26.98</td>
</tr>
<tr>
<td><strong>Training college</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belvedere</td>
<td>6</td>
<td>9.52</td>
</tr>
<tr>
<td>Gweru</td>
<td>31</td>
<td>49.20</td>
</tr>
<tr>
<td>Hillside</td>
<td>23</td>
<td>26.51</td>
</tr>
<tr>
<td>Mutare</td>
<td>2</td>
<td>3.17</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td><strong>Teaching experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–3 years</td>
<td>28</td>
<td>44.44</td>
</tr>
<tr>
<td>4–6 years</td>
<td>26</td>
<td>41.27</td>
</tr>
<tr>
<td>7–9 years</td>
<td>6</td>
<td>9.52</td>
</tr>
<tr>
<td>10–12 years</td>
<td>3</td>
<td>4.76</td>
</tr>
</tbody>
</table>

as teachers on the two year post-A level program which is increasingly becoming adopted by the colleges. More than three quarters (75.71%) had trained at Gweru and Hillside teachers’ colleges and the remainder had trained either at Mutare (2) or at Belvedere (6).

Table 4 shows the distribution of respondents according to the actual year they had graduated as self-reported on the academic record release form. All respondents had graduated
Table 4. Distribution of BEd science teachers according to the year in which they graduated from a teacher training college (N = 63)

<table>
<thead>
<tr>
<th>Year of Graduation</th>
<th>n</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>2</td>
<td>3.17</td>
</tr>
<tr>
<td>1985</td>
<td>7</td>
<td>11.11</td>
</tr>
<tr>
<td>1986</td>
<td>4</td>
<td>6.35</td>
</tr>
<tr>
<td>1987</td>
<td>9</td>
<td>14.28</td>
</tr>
<tr>
<td>1988</td>
<td>9</td>
<td>14.28</td>
</tr>
<tr>
<td>1989</td>
<td>9</td>
<td>14.28</td>
</tr>
<tr>
<td>1990</td>
<td>19</td>
<td>30.16</td>
</tr>
<tr>
<td>1991</td>
<td>3</td>
<td>4.76</td>
</tr>
<tr>
<td>1992</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>100.00</td>
</tr>
</tbody>
</table>

between the years 1981 and 1992 corroborating the data of Table 3 which showed their experience ranged from one to twelve years. The BEd program requires that applicants for admission have at least two years post-certification work in an educational institution. For many the requirement translates to two years teaching experience in a secondary school. For all except 4 respondents, 3 who graduated in 1991 and 1 who graduated in 1992, this admission criterion was met.

Academic performance in college and university

Table 5 and Table 6 show the academic performance of the science teachers during pre-service teacher preparation and during Part I of the degree program respectively. Table 5 shows the three major components, teaching practice [TP], theory of education [TOE], and the main teaching subject [MTS], in this case science, in which science teachers have to pass in order to satisfactorily complete their pre-service teacher preparation. Their academic performance, as reflected in the distribution according to grades, was essentially the same in the three areas in which they were assessed. Just over 50% obtained a 'C' grade and around 40% received a 'B' grade in all three sections.
Table 5. Academic standing of science teachers during pre-service teacher training (N = 66)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Teaching Practice</th>
<th>Theory of Education</th>
<th>Science</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>B</td>
<td>25</td>
<td>42.37</td>
<td>24</td>
<td>41.48</td>
</tr>
<tr>
<td>C</td>
<td>32</td>
<td>54.24</td>
<td>29</td>
<td>50.00</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>3.39</td>
<td>4</td>
<td>6.90</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>0.00</td>
<td>1</td>
<td>1.72</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td></td>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

The total is not 66 due to 8 missing or incomplete records.

Table 6 shows their performance in the final examinations given at the end of Part I of the BEd program in 1993. The scheme of assessment adopted for all courses and programs was as follows: 1 (first division) = 80%+; 2.1 (upper second division) = 70%–79%; 2.2 (lower second division) = 60%–69%; 3 (third division) = 50%–59%; and fail = below 50% (University of Zimbabwe, 1994; p. 188). The subjects shown are as stipulated in the regulations which specify that in the first year "each student shall study three courses in the selected subject and one and half professional courses" (University of Zimbabwe, 1994; p. 337). ESME 101, 102 and 201 are the professional courses and the rest of the academic subject courses are described in Table 6. As can be discerned from Table 6, there were hardly any first class (1) or upper second (2.1) division scores. Instead, for all subjects, there is a lot of bunching in the lower second division (2.2) and third class (3.0). This should not be surprising given the fact that a majority of these students were already B and C grade students at the end of their pre-service teacher preparation as shown in Table 5. For the science curriculum theory ESME 101, a disproportionately large number (43) or 65.15% obtained a third class pass, i.e., their criterion referenced scores lay somewhere between 50% and 59%. This reflects a general laxity in performance which might reflect a general lack of attention to curriculum issues in pre-service teacher preparation or a poor attitude toward it by the students.
Table 6. Academic standing of BEd science teachers at the end of Part I of their in-service degree program (N = 66)

<table>
<thead>
<tr>
<th>Classification</th>
<th>ESM 101</th>
<th>ESM 102</th>
<th>ESM 103</th>
<th>ESM 101</th>
<th>ESM 102/201</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Class (1.0)</td>
<td>10 (15.15)</td>
<td>6 (9.09)</td>
<td>2 (3.03)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
<td>18 (5.45)</td>
</tr>
<tr>
<td>Upper Second (2.1)</td>
<td>18 (27.27)</td>
<td>11 (16.67)</td>
<td>13 (19.70)</td>
<td>3 (4.54)</td>
<td>14 (21.21)</td>
<td>59 (17.88)</td>
</tr>
<tr>
<td>Lower Second (2.2)</td>
<td>31 (46.97)</td>
<td>32 (48.48)</td>
<td>25 (37.88)</td>
<td>20 (31.82)</td>
<td>42 (63.64)</td>
<td>150 (45.45)</td>
</tr>
<tr>
<td>Third Class (3.0)</td>
<td>7 (10.61)</td>
<td>17 (25.76)</td>
<td>26 (39.39)</td>
<td>43 (65.15)</td>
<td>10 (15.15)</td>
<td>103 (31.21)</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>66</td>
<td>330</td>
</tr>
</tbody>
</table>

Note. BEd Part I courses were as follows:

1. ESM 101 was the pre-requisite course. For the chemistry group this covered physics and statistics, for the biology group this covered chemistry and statistics, and for the physics group it covered mathematics and computing.

2. ESM 102 was as follows: ESMB 102 biology – plant kingdom; ESMC 102 chemistry – introduction to atomic structure and organic chemistry; and ESMP 102 physics – mechanics.

3. ESM 103 was as follows: ESMB 103 biology – animal kingdom; ESMC 103 chemistry – analytical chemistry; and ESMP 103 physics – thermal physics and properties of matter.

4. ESME 101 was Science Curriculum Theory.

5. ESME 101/201 was Science A level Methods I and II.

Table 7 shows the correlation matrix for the performance of the respondents in the three sections of the pre-service teacher preparation program and on the five courses in Part I of the BEd program. Fourteen (14) cases with missing data were deleted by the computer program leaving 52 valid cases in the correlation matrix. It was established that for 50 degrees of freedom, i.e. N–2 of the 52 valid cases, the critical value of the correlation coefficient was .23 for a one-tailed probability level of .05 and .32 for the .01 significance level (Ary, et al, 1990; Hinkle, et al., 1988). A positive relationship was expected. The theory of education (TOE) scores were not correlated to the teaching practice (TP) scores (r = .02) but were modestly but significantly correlated to the
Table 7. Correlation matrix for academic performance of BEd science teachers on the pre-service teacher training program and on the BEd program (N = 52)

<table>
<thead>
<tr>
<th></th>
<th>TP</th>
<th>TOE</th>
<th>MTS</th>
<th>ESM 101</th>
<th>ESM 102</th>
<th>ESM 103</th>
<th>ESME 101</th>
<th>ESME 102/201</th>
<th>TTC Score</th>
<th>BEd I Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOE</td>
<td>.02</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTS</td>
<td>.25*</td>
<td>.29*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 101</td>
<td>.27*</td>
<td>.07</td>
<td>.16</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 102</td>
<td>.12</td>
<td>-.01</td>
<td>.26*</td>
<td>.54**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 103</td>
<td>.09</td>
<td>.00</td>
<td>.22</td>
<td>.55**</td>
<td>.60**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESME 101</td>
<td>-.07</td>
<td>.25*</td>
<td>.18</td>
<td>.11</td>
<td>.29*</td>
<td>.26*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESME 102/201</td>
<td>.24*</td>
<td>.12</td>
<td>.23*</td>
<td>.09</td>
<td>.07</td>
<td>.07</td>
<td>.26*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC Score</td>
<td>.60**</td>
<td>.65**</td>
<td>.77**</td>
<td>.24*</td>
<td>.18</td>
<td>.16</td>
<td>.18</td>
<td>.30*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BEd I Score</td>
<td>.19</td>
<td>.11</td>
<td>.31*</td>
<td>.75**</td>
<td>.82**</td>
<td>.80**</td>
<td>.53**</td>
<td>.32*</td>
<td>.30**</td>
<td>1</td>
</tr>
</tbody>
</table>

* Correlation significant at the .05 level.

** Correlation significant at the .01 level.

**Note.** (1) Codes for pre-service teacher preparation scores were: TP = Teaching practice; TOE = Theory of education; MTS = Main teaching subject (Science); TTC Score = Overall pre-service teacher training college score.

(2) Codes for BEd Part I scores were: ESM 101 = Pre-requisite: Chemistry group covered physics and statistics; Biology group covered chemistry and statistics; and Physics group covered mathematics and computing; ESM 102 = ESMB 102 biology – plant kingdom; ESMC 102 chemistry – introduction to atomic structure and organic chemistry; and ESMP 102 physics – mechanics; ESM 103 = ESMB 103 biology – animal kingdom; ESMC 103 chemistry – analytical chemistry; and ESMP 103 physics – thermal physics and properties of matter; ESME 101 = Science Curriculum Theory; ESME 101/201 = Science A level Methods I and II; BEd Score = Overall score on BEd Part I.
teaching subject (MTS) scores ($r = .29$). As would be expected, the theory of education, teaching practice, and science scores are positively and significantly correlated to the overall teacher training program score (TTC). The overall performance in the pre-service teacher preparation program was positively and significantly correlated to the overall BEd performance in Part I ($r = .30$). Only the teaching subject score (MTS) was significantly correlated to the BEd score ($r = .31$). Both the pre-service teaching practice ($r = .19$) and theory of education ($r = .11$) scores bore little and non-significant relationship to the BEd score perhaps reflecting the greater emphasis in the science academic content in the degree program. Overall performance on the pre-service teacher preparation program was significantly ($r = .30$) related to overall performance on Part I of the degree program.

Scores in the academic courses ESM 101, 102 and 103 were positively and significantly related even at the .01 probability level. Interestingly their scores in ESM 101 (the pre-requisite science course) were not correlated to scores in the professional courses, ESME 101 science curriculum theory ($r = .11$) and ESME 102/201 A Level science methods ($r = .09$). There was also no relationship between the academic science content courses ESM 101, 102, and 103 and the A level methods courses ESME 102/201. The A level methods course scores were only modestly but non-significantly correlated to the science curriculum theory course ($r = .26$). In general the two professional courses do not seem to have a significant relationship with the academic content courses. A factorial analysis of variance technique (Table 8) established that differences in the overall BEd performance scores or pre-service teacher preparation program scores did not exist when respondents were grouped according to the science subject in which they specialized.

**Social and ethnic backgrounds of science teachers**

Table 9 shows the religious orientation and the regional affiliation of science teachers and Table 8 shows their social and ethnic backgrounds. Table 9 shows that 45 teachers representing 71.43% of the sample grew up in a religious environment in which both Christianity and traditional religions were practiced. It is not uncommon to find indigenous Zimbabweans.
Table 8. Analysis of variance comparison of BEd science teachers TTC scores and BEd scores by science specialization group

<table>
<thead>
<tr>
<th>Source</th>
<th>DF:</th>
<th>Sum Squares:</th>
<th>Mean Square:</th>
<th>F-test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTC Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>2</td>
<td>.9400</td>
<td>.4700</td>
<td>2.8038</td>
</tr>
<tr>
<td>Within groups</td>
<td>56</td>
<td>9.3877</td>
<td>.1676</td>
<td>p = .0691</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>10.3277</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEd Part I Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>2</td>
<td>.0740</td>
<td>.0370</td>
<td>.3961</td>
</tr>
<tr>
<td>Within groups</td>
<td>63</td>
<td>5.8874</td>
<td>.0935</td>
<td>p = .6746</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>5.9614</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Acknowledging Christianity and still practice traditional religion as might be necessary for given circumstances (Bourdillon, 1987). Only two respondents claimed to have grown up in a non-religious environment. When asked to indicate their current religious practices, 42.86% indicated both Christianity and traditional, 41.27% indicated Christianity, and 14.28% were non-religious. In this sample, hardly anyone was purely traditionalist in religious belief. There was a significant positive correlation (.37) between the religious environment teachers grew up and the religious practices they now adopted. There seems to be no difference in the religious practice of science teachers and the religious practice under which they had grown up.

Table 9 also shows which of the nine administrative regions of Zimbabwe respondents came from and where they worked. At least 10 teachers indicated Masvingo, Harare, Manicaland, and the Midlands as the regions from which the teachers came. Many of the teachers worked in Masvingo (25) and Manicaland (10) before registering for the BEd program. The region in which the teachers worked seem different from the regions of which they originally came. This in part is due to Ministry of Education policies which require deployment of newly qualified teachers to regions or areas of greatest teacher shortage. More than 90% spoke Shona and of these, three (4.76%) reported themselves to be bilingual, i.e., in addition to Shona they also spoke Ndebele (Table 10).
Table 9. BEd science teachers' religious and regional backgrounds (N = 63)

<table>
<thead>
<tr>
<th>Social Characteristic</th>
<th>Frequency</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Past Environment</td>
<td>Present Practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Religious practice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both Christian and traditionalist</td>
<td>45</td>
<td>71.43</td>
<td>27</td>
</tr>
<tr>
<td>Christian</td>
<td>13</td>
<td>20.63</td>
<td>26</td>
</tr>
<tr>
<td>Traditionalist</td>
<td>3</td>
<td>4.76</td>
<td>1</td>
</tr>
<tr>
<td>Non-religious</td>
<td>2</td>
<td>3.17</td>
<td>9</td>
</tr>
<tr>
<td>Administrative region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harare</td>
<td>10</td>
<td>15.87</td>
<td>4</td>
</tr>
<tr>
<td>Midlands</td>
<td>12</td>
<td>19.05</td>
<td>8</td>
</tr>
<tr>
<td>Mashonaland Central</td>
<td>2</td>
<td>3.17</td>
<td>4</td>
</tr>
<tr>
<td>Mashonaland East</td>
<td>8</td>
<td>12.70</td>
<td>3</td>
</tr>
<tr>
<td>Mashonaland West</td>
<td>3</td>
<td>4.76</td>
<td>4</td>
</tr>
<tr>
<td>Manicaland</td>
<td>10</td>
<td>15.87</td>
<td>10</td>
</tr>
<tr>
<td>Masvingo</td>
<td>16</td>
<td>25.40</td>
<td>25</td>
</tr>
<tr>
<td>Matebeleland North</td>
<td>0</td>
<td>0.00</td>
<td>2</td>
</tr>
<tr>
<td>Matebeleland South</td>
<td>1</td>
<td>1.58</td>
<td>3</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>1.59</td>
<td>0</td>
</tr>
</tbody>
</table>

The ethnic groups to which they belonged are shown in Table 10. Of the majority (63.49%) 23 were Kalanga and 17 were Korekore. Table 10 also shows that a majority (69.84%) grew up in rural areas or in the countryside. The rest grew up at a mining center (23.81%), or in a city (3.17%), or commercial farm (3.17%).

Table 11 summarizes the responses of science teachers concerning the level of literacy, education, and occupation of their parents. A very small number of parents representing less than 8% were reported as unable to read and write (5 mothers and 2 fathers). A slightly greater number, 8 mothers and 6 fathers, were reported to have had no formal education which would imply that some parents were able to gain literacy, i.e., the ability to read and write informally. In general the data in Table 11 show that the majority of parents had some literacy and that the majority,
Table 10. BEd science teachers social and ethnic backgrounds (N = 63)

<table>
<thead>
<tr>
<th>Social or Ethnic Characteristic</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
</tr>
<tr>
<td>Local language spoken</td>
<td></td>
</tr>
<tr>
<td>Shona</td>
<td>55</td>
</tr>
<tr>
<td>Ndebele</td>
<td>5</td>
</tr>
<tr>
<td>Both Shona and Ndebele</td>
<td>3</td>
</tr>
<tr>
<td>Background growing up</td>
<td></td>
</tr>
<tr>
<td>Rural/countryside</td>
<td>44</td>
</tr>
<tr>
<td>Commercial farm</td>
<td>2</td>
</tr>
<tr>
<td>Mining center</td>
<td>15</td>
</tr>
<tr>
<td>Urban center/city</td>
<td>2</td>
</tr>
<tr>
<td>Ethnic Group</td>
<td></td>
</tr>
<tr>
<td>Ndebele</td>
<td>1</td>
</tr>
<tr>
<td>Kalanga</td>
<td>23</td>
</tr>
<tr>
<td>Karanga</td>
<td>4</td>
</tr>
<tr>
<td>Manyika</td>
<td>2</td>
</tr>
<tr>
<td>Korekore</td>
<td>17</td>
</tr>
<tr>
<td>Zezuru</td>
<td>4</td>
</tr>
<tr>
<td>Ndau</td>
<td>2</td>
</tr>
</tbody>
</table>

over 68% of mothers and more than 53% of fathers, had at least received primary level education. A negligible number had education above the Zimbabwe Junior Certificate Level (ZJC) or the equivalent of grade 9. While level of literacy and level of education is usually in favor of males in Zimbabwe, for this sample of teachers, there was a small difference between the reported literacy and educational levels of the teachers’ mothers and fathers.

Turning to occupations of their parents, more than 80% of the respondents indicated that their mothers were not in the employment sector. Twenty seven (42.86%) mothers were reportedly "unemployed" and twenty four (38.09%) were reportedly subsistence farmers, a role which married females have been acknowledged to participate in significantly (Gelfand, 1973). For comparison, it must be observed that only 17 fathers, i.e., less than 27%, were unemployed or were communal
Table 11. Literacy, education, and employment backgrounds of BEd teachers' parents (N = 63)

<table>
<thead>
<tr>
<th>Parent Variable</th>
<th>Mother</th>
<th>Father</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Literacy level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No literacy (unable to read and write)</td>
<td>5</td>
<td>7.94%</td>
</tr>
<tr>
<td>Low literacy (just able to read and write)</td>
<td>39</td>
<td>61.90%</td>
</tr>
<tr>
<td>High literacy (proficient in reading and writing)</td>
<td>19</td>
<td>30.16%</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal education</td>
<td>8</td>
<td>12.70%</td>
</tr>
<tr>
<td>Primary education</td>
<td>43</td>
<td>68.25%</td>
</tr>
<tr>
<td>Junior secondary (ZJC)</td>
<td>9</td>
<td>14.28%</td>
</tr>
<tr>
<td>O Level or Grade 11</td>
<td>2</td>
<td>3.17%</td>
</tr>
<tr>
<td>Higher education (A level, college or university)</td>
<td>1</td>
<td>1.58%</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>27</td>
<td>42.86%</td>
</tr>
<tr>
<td>Communal farmer</td>
<td>24</td>
<td>38.09%</td>
</tr>
<tr>
<td>Employed, non-skilled or general hand</td>
<td>3</td>
<td>4.76%</td>
</tr>
<tr>
<td>Employed, skilled professional or administrative</td>
<td>9</td>
<td>14.28%</td>
</tr>
</tbody>
</table>

farmers. Forty six were employed, 30.16% as general hands (help) and 42.86% were in skilled professional or administrative jobs. Given the low level of education reported in Table 11 for these parents, it may be that many of the "skilled" parents were clerks, a very common pre-independence job for black Zimbabweans.

Analysis of the demographic characteristics of the sample suggests that it was fairly homogenous. The teachers were relatively young with under 10 years of teaching experience. Their academic and professional qualifications were appropriate at this point in time of their careers. It appears that their academic performance on both the preservice teacher training and on the BEd program was average. The majority grew up in the countryside (rural area) and in a religious environment which was a mix of Christian and traditional religions and appear to cling to those religious practices. Their parents, both mother and father, were literate having acquired at least
primary level education. The homogenous appearance of this sample is related to the program requirements and to the small population size of teachers in the BEd program. This is expected to depress correlations obtained with dependent measures (Hinkle, et al., 1988).

Summary

This chapter summarized the research design and methodology for gathering and analyzing data used in the study. Data concerning validity and reliability of instruments as well as the results of analyzing the rest of the data collected are summarized, organized, described, and interpreted in Chapter IV, V, VI, and VII. Chapter IV describes the indigenous world-view and teachers' qualitative assessment of its interaction with science education; Chapter V describes the orientation of science teachers to indigenous culture and its relationship to their beliefs concerning the nature of science, environmental conservation, and instructional ideology; Chapter VI describes science teachers' perception of the nature of science and scientific knowledge and instructional ideology; Chapter VII describes science teachers awareness of a science and technology related societal issue, environmental conservation; and Chapter VIII contains a summary, conclusions, and discussion of the findings.
CHAPTER IV. SCIENCE TEACHERS' ASSESSMENT OF THE INTERACTION OF INDIGENOUS AFRICAN CULTURE WITH SCIENCE EDUCATION IN ZIMBABWE

A paper to be submitted to the Zimbabwe Journal of Educational Research

Overson Shumba

Abstract

This article reports on science teachers' experiences and knowledge of the nature and nurture of interaction of traditional culture with science education in Zimbabwe. Structured content analysis was applied on 58 samples of open-ended response text as well as on the transcript of a 14 member random sample focus group interview leading to a qualitative profile of teachers' perceptions. In both the written and oral responses, teachers identified multiple dimensions of traditional culture which interact with science education in a way which inhibited the adoption and spontaneous application of science and its values to problem situations. The focus group interview showed that some science teachers held strong traditional values and beliefs. It also showed that teachers believed that factors concerning the curriculum were more important than socio-cultural variables in inhibiting the effective adoption and utilization of science and its values. Implications of the indigenous knowledge and experiences of teachers in science education are discussed.

Background

In non-western societies, it is increasingly becoming clear that understanding the contribution of a traditional culture's world-view to science learning is significant to the adoption of science, its methods, and values (Ogawa, 1986; Ogunniyi, 1986 & 1988; Cobern, 1993). As Cobern (1993) notes, in developing countries, there is need to ask "questions about world-view and the compatibility of various non-western world views with modern science" (p. 1). The issue of cultural
context with reference to African countries is also articulated by Morris (1983) who notes that education does not take place in a cultural vacuum, "it occurs against the background of a view of the world and of humanity's place in it which are characteristics of a particular society" (p. 97). Morris (1983) further notes that African students' commitment to science is sustained only through the duration of courses of study and "once the ordeal of courses of study is over, and they can relax again, they return to the security of their earlier beliefs" (p. 23). According to Odhiambo (1968), it is essential for African students to become imbued with the spirit of science, with a scientific way of looking at nature, and with a scientific manner of approaching new problems. He therefore perceived that "the African must be saved (sic) from living two worlds- one of belief, and the other of natural science" or else face the situation where people accept "the products and procedures of the technological aspects of science while remaining perplexed with the inner spirit of science itself" (Odhiambo, 1968; pp. 45-46). Unfortunately, in traditional cultures, a commitment to science, and the spontaneous application of scientific approaches to problem situations may be absent sometimes even among science teachers. This assessment can be extrapolated from Shrigley's (1983) recollection and description of his experience in a Nigerian teachers' college. For example, he claims that he found:

students who were seeking simple answers to complex scientific phenomena, distressed by the tentative nature of the scientific enterprise. There was a tendency to embrace, even tongue-in-cheek, information having a superstitious base, but at least a definite answer, in preference to wrestling with several scientific alternatives. To illustrate the frustration that the lack of sure and fixed knowledge can generate, one student made a public appeal that I teach only what scientists were sure of! (p. 427)

These observations raise the question of influence and commitment to an indigenous culture and world-view on the acquisition of scientific literacy (Cobern, 1993). As the American Heritage Dictionary defines it, world-view is the "overall perspective from which one sees and interprets the world" (p. 2058). World-views are consistent and not easily changeable and thus there is need to understand how the world-view acquired in the first culture, in this case traditional culture,
interacts with student processes of acquiring and adopting the scientific world-view, the second culture.

Increased attention to traditional culture and world-view in science education has elevated awareness that for attainment of a reasonable level of scientific literacy in non-western societies reference to the cultural referents of the learner or for that matter those of the "indigenous" teacher is necessary. As can be deduced from constructivist theory, socio-cultural environments provide students with prior knowledge and experiences to deal with reality. The prior experience and knowledge gained from the culture-of-origin serves to provide alternative conceptions which influence the acquisition of new forms of knowledge such as scientific views of nature and ways of thinking (Cobern, 1993; Horton, 1982; Ogawa, 1986; Ogunniyi, 1988). Ogawa (1986) proposed that science should be "relativized" so that it can be seen within the context of students' indigenous culture. Ogunniyi (1988) extending the same thinking to the context of African societies asserted:

It seems that if the scientific world view is to succeed in Africa and perhaps other traditional societies, the aim should be geared towards accommodation rather than assimilation. The African should not be presented science from a superior vantage point but as a way he can cope better with certain experience. ... The aim of science education I am proposing here should not be to supplant or denigrate a traditional culture but to help people meet modern challenges. (p. 8)

According to Ogawa (1986) and Ogunniyi (1988), science is a second culture for students in many non-western societies and hence potential for conflict is always present. Conflict between the indigenous culture and science culture can arise in part because some science-related topics may be taboo to certain cultures and students (McGinnis, 1992). For example, in some communities in Zimbabwe, handling bones or creatures such as mice, owls, and other nocturnal animals and birds is a taboo tied to the belief in the practice of witchcraft. On matters concerning sex education, traditionalists are purists and so sexual organs and other sexuality-related matters are considered sacred and secret (Aschwanden, 1982). According to McKinley, Waiti, and Bell (1992) conflict can arise between science and traditional world-views because they have different attitude-value complexes comparable to those found in Zimbabwe; there the indigenous culture emphasizes
obedience and reverence of an adult as an authority figure and a source of knowledge and wisdom (Aschwanden, 1982; Gelfand, 1973; Bozongwana, 1982; M. Bourdillon, 1987). Children are not always privileged to query or contribute to the knowledge or to decisions elders make; the knowledge submitted by elders is often final and absolute. Teaching children to be critical thinkers and to ask questions in science education, while not impossible, conflicts with some cultural emphasis on views concerning 'normal behavior' such as conformity, accepting top–down procedures for problem solving, and endorsing cosmological or spiritual forms of causal explanation and other behaviors. Indigenous African traditional culture and world–view even influences the way adult students who have had a reasonable level of experience and background in school science education to observe and perceive phenomena using culture–of–origin conceptions. This is illustrated in a recent study of pre–degree science students in Nigeria where Jegede and Okebukola (1991a) observed that 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 high level of religious belief. They therefore tentatively concluded that "it does seem that African traditional beliefs exerted the most influence on observational tasks in comparison with gender and religious affiliations" (p. 43).

Other differences arise because science culture and indigenous culture thrive on different philosophies and hence utilize a different basis for explaining and experiencing phenomena as well as various forms of reality. The preceding overview of the literature demonstrates that the indigenous world–view in non–western culture is different from the scientific world–view and thus deserves meticulous attention of science education professionals and researchers. Some African traditional values and beliefs are at variance with goals and outcomes purported in science education and hence a high level of commitment by either the teacher or the student to those values and beliefs can be expected to have a non–complimentary relationship and even perhaps debilitating effect in science education. Indigenous teachers are confronted on a day–to–day basis by contradictions between their cultural world–view and the scientific world–view as well as
between the scientific world-view and their students' world-view. Studies are therefore needed that isolate and assess how specific aspects of indigenous world-view interact with science education, especially how indigenous science teachers view those interactions.

This article reports on the results of a study which assessed the experience and perceptions of secondary science teachers concerning the nature and nurture of interactions between specified aspects of indigenous culture and science education in Zimbabwe. Since the majority of science teachers in Zimbabwe grow up or teach in an indigenous socio-cultural environment, it was assumed that they had acquired knowledge of the indigenous African world-view and that they had experience on its interaction with science education. An awareness of the cultural context and world-view in which they teach was thought to enable them to better exemplify and link their subject domain to cultural realities and everyday experiences of their students. They have to demonstrate to their students the strengths and weakness of traditional culture relative to science as a way of viewing the universe and as a way of knowing (Ogawa, 1986; Ogunniyi, 1988). The article reports on the results of analyzing indigenous Zimbabwean science teachers' written and oral descriptions of their experiences and examples of the interaction of specific dimensions of traditional culture with science education and their implications.

Research questions and conceptual framework

Research questions

This paper aims at describing, analyzing, and interpreting science teachers' examples and experiences on the interaction of indigenous culture with science education in the context of Zimbabwe. In particular the study sought to provide answers to the three questions.

1. What kind of socio-cultural environment constitutes traditional culture in Zimbabwe?
2. What is the perception and experience of science teachers concerning the interaction of indigenous traditional culture and science education?
3. What are the implications of indigenous culture and world-view to science education?
It was hypothesized that science teachers would perceive indigenous culture as interfering with students' ability to acquire and adopt scientific knowledge and processes. This expectation is rationalized by the cultural context in which the study took place.

The first research question was especially concerned with giving the cultural background and context of the study. The second and third questions were answered by analyzing 58 written responses to the open-ended question:

Please give an assessment of how specific aspects of traditional Shona or Ndebele culture (practices, values, customs, or beliefs) influence indigenous Zimbabwean students' learning and adoption of science and its values. Feel free to describe any examples from your personal learning or teaching experience.

Triangulation was achieved via analyzing the content of a 14 participant face-to-face semi-structured and random sample focus group interview. Open responses permitted science teachers to describe and to evaluate how specific cultural beliefs and practices influenced the extent to which the scientific world-view was internalized and assimilated into the cognitive, affective and socio-cultural behavior repertoires of indigenous students.

Conceptual framework

According to Marton (1986), analysis of open responses and interviews can lead to understanding of "the qualitatively different ways in which people experience or think about various phenomena" (p. 31). On the other hand, Horton (1971 & 1982) observed that aspects considered "common sense" in western culture and in science may not be applicable to African culture.

In this study, teachers were specifically asked to identify experiences and examples of indigenous culture and to elaborate on how, in their experience or opinion, those aspects interacted with science education. Their examples and experiences are described and interpreted in the context of the indigenous traditional culture of Zimbabwe. In discussing the findings, this study compares phenomena and issues in the way they are perceived in indigenous culture to how they should be perceived in science education. The study articulates differences between indigenous thought and
beliefs and science in the belief that these differences should be the focus of attention in order to meaningfully integrate indigenous thought and practice with science education.

Methodology

The two approaches used to collect data for this article are open responses to a written question and a structured focus group interview as described by Krueger (1988). The study used a sample of secondary science teachers enrolled in Part II of the inservice Bachelor of Education (BEd) degree program at the University of Zimbabwe in 1994. The teachers on the program came from all nine educational administrative regions in Zimbabwe and all of them were certified and experienced in teaching school science in form one through four (grades 8–11). On the BEd program, teachers are prepared to teach science to all levels of the secondary sector including Form 6 (grade 13). Upon completion they are also expected to be able to participate in curriculum development, to teach in teachers’ colleges, and to service other divisions of the Ministries of Education (University of Zimbabwe, 1994). The BEd science teachers were distributed unequally among chemistry (21), physics (27), and biology (18) specialties. All the teachers except 3 responded to the questionnaire survey component of the main study. Of the 63 responding to the questionnaire survey, 58 (96.06%) provided written open-ended responses addressing the interaction of culture and science education. The 58 responses ranged from a single sentence to almost two double spaced pages; this text provided some of the data analyzed in this article. Further, approximately 20% of the teachers were randomly selected to participate in a focus group interview designed to probe their perceptions on the interaction of culture and science instruction. Four students were randomly picked from the chemistry and biology groups respectively and 6 students were picked from the physics group to make up a 14-member focus group. Krueger (1988) suggests that a focus group must be small enough for everyone to have opportunity to share insights and yet large enough to provide diversity of perceptions (p. 27).

Krueger defines a focus group as a “carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment” (p. 18). It
has the advantage of "high face validity, which is due in large part to the believability of comments from participants" and also that "people open up in focus groups and share insights that may not be available from individual interviews, questionnaires, or other data sources" (Krueger, 1988; p. 42). The interview lasting one hour fifteen minutes was semi-structured following a pre-planned questioning route to elicit open-ended responses which were tape-recorded; probing was done at appropriate junctures using pre-planned questions as well as impromptu questions to follow up responses. Overall, the focus group attempted to gain insight into the nature of interaction between traditional culture and science education in Zimbabwe. It therefore sought science teachers': (i) views and experiences regarding the role of science in the school curriculum as well as the importance of cultural beliefs and practices in those roles; (ii) examples of specific traditional beliefs and practices and their perceived influence on the way they or their students learned science; (iii) suggestions by which indigenous culture based beliefs and preconceptions were dealt or should be dealt with in science education; and (iv) opinions on the extent to which science was internalized and utilized spontaneously among Zimbabweans. The questioning route is appended to this paper as Appendix I.

Data analysis

Open response content analysis

The technique employed to analyze the open response content text was content analysis (Adams, 1982; Lee & McLean, 1978; Tesch, 1990). Content analysis refers to a system of classification which allows the researcher to identify primary characteristics of the content, make inferences about the nature of the content, and interpret the content so that it is meaningful (Lee & McLean, 1978; p. 3). Tesch (1990) defines the content analysis steps as involving category development and refinement, coding the content of text according to the categories, aggregating the coded text into its categories, counting the frequency of occurrence of coded text in categories, and describing and interpreting the meaning of the categorized data to arrive at substantive conclusions. Analysis of open response text (ORT) and the focus group transcript (FGT) was done to identify and
categorize experiences and knowledge of science teachers concerning the interaction of culture with science education. However, the quantification step involving counting the number of respondents who mentioned a category was done only for the ORT (Table 1) but not for the FGT where both negative and positive responses were expected and obtained from a small number of informants. A more descriptive approach citing examples and excerpts to portray view-points of the focus group was adopted.

**Validity and reliability**

Validity of the open response data lies in the believability of the respondents' original comments and contributions (Krueger, 1988; Marton, 1986; Tesch, 1990). In this study, the two analysts from two independent but comparable cultures (Zimbabwe and Nigeria) could agree on the content categories as representing attributes of a traditional African culture. Further evidence of validity was based on the fact that respondents in this study gave examples and descriptions of indigenous culture which were supported by the literature and by the experts consulted.

The intent of the content analysis was to arrive at a relatively objective summary of what the respondents perceived concerning the influence of aspects of indigenous culture in science education. Scott and Wertheimer (1962) defined objectivity as "reliability or agreement among independent observers" and that a coding judgment can be said to be objective "to the extent that it is duplicated by another trained observer who makes an independent judgment based on the same data" (p. 187). In order to estimate the reliability of coding in this study, a coefficient of inter-rater agreement $\pi$ was computed (Scott, 1955; Scott & Wertheimer, 1962). $\pi(\pi)$ indicates the extent to which two independent content analysts agree beyond the level that would be expected by chance. It is the appropriate indicator of reliability when two analysts code text on a nominal scale such as the case when they either "agree" or "disagree". $\pi(\pi)$ corrects for chance "agreement" which often elevates the observed percentage agreement when only a few of the categories are used with appreciable frequency.
Procedurally, reliability was assessed in the following manner. After the initial development of the categories by the researcher, a second analyst who was a paid research assistant was trained in coding 5 randomly selected samples of text as part of the assistantship duties. At the training session, the purpose of the content analysis, attributes of the categories, and the coding scheme were explained. Table 1 shows the final categories, their codes, and the dimensions of culture they addressed. For the training sample text, perfect agreement was achieved and thus the analysts proceeded to analyze and code all samples of text independently.

Analysis was conducted by reading the open response text and noting the category into which the content could be placed. For every respondent's text, each category was coded only once even if it appeared several times in the same text. This means that for each text sample, the analysts identified the number of exclusive categories into which the manifest content of the text could be placed. Therefore, frequency counts in Table 1 indicate the number of text samples and hence the number of respondents out of the 58 identifying each category. Once independent coding was completed, the two analysts met to discuss and compare the results of their analyses for each sample of ORT. Relatively minor disagreements were found and mutually resolved. For example, one of the analysts was placing any text mentioning the word 'sex' into category 1 even if it did not refer to 'sex or gender bias' and twice coded a category 'family structure' which was agreed to be absent in the text. There also had been an accidental omission to code text of one respondent but there was no other evidence of systematic mechanical error. The post-discussion agreement level was almost 95% and the value of $\pi$ was .93 showing a high level of reliability of the content analysis.

Results

Open response data

Table 1 shows the results of the structured content analysis of written open-ended responses. A summary of triangulation data based on a focus group interview is presented later in Figure 1. All of the open response text content could be classified under the 10 categories or themes describing or
evaluating the consequence of having indigenous world-view in science education. Marton (1986) described categories of content analysis as "pools of meaning"; in this study 8 of the categories in Table 1 each represented a dimension of indigenous culture and/or world-view. Two categories (9 & 10) in Table 1 were created for the classification of evaluative responses, i.e., they represent, respectively, an evaluation of the negative or positive consequence of an aspect of traditional culture. Practically all science teachers' written responses (94.83%) mentioned or exemplified a negative interaction of indigenous culture with science education (category 9). The teachers explained that the negative interaction was due to the fact that the basis or logic of explanation and interpretation of similar experiences in indigenous culture was different than in science education. It was generally acknowledged that indigenous culture and science education are two systems which represent two independent ways of thinking and explaining phenomena. Fewer than 20% of the respondents exemplified practices in indigenous culture which could be useful and complimentary to science education. The focus group endorsed all except one category "goal structure" and corroborated the perception that indigenous culture based beliefs or explanations could be carried alongside, independently, or in spite of the scientific explanation. The rest of the categories in Table 1 exemplify the specific dimensions of indigenous culture thought to interact with science education. All of these categories except "goal structure" were cited in so far as knowledge and belief about them had a negative implication in science education. Their distribution were as follows: relationship with nature (87.93%), causality (32.21%), reverence for authority (29.31%), religious ideology (27.59%), orientation to change (24.14%), sex or gender bias (20.69%), procedures for problem solving (20.69%), and goal structure (8.62%).

Table 1 shows that 51 respondents (87.93%) identified beliefs and practices associated with category 8 "relationship with nature" as problematic in science education. Within this category, 33 respondents (56.90%) identified belief and practice in the use of supernatural powers, e.g., witchcraft as detrimental to science education. The single most cited example occurring in a total of 31 text samples was the belief that lightning could be created, captured or directed by malevolent
<table>
<thead>
<tr>
<th>Content Categories, Codes, and Description</th>
<th>Analyst I</th>
<th>Analyst II</th>
<th>Agreed Total</th>
<th>% of sample</th>
<th>Rank</th>
<th>Focus Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sex or gender bias [Sex]: identifies belief that social roles should be delineated by gender; inequality between sexes; treatment of females as minors; male dominance.</td>
<td>12</td>
<td>13</td>
<td>12</td>
<td>20.69</td>
<td>7.5</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Reverence for authority figures [Aut]: identifies belief that locus of control and wisdom lie with elders; authoritarianism; emphasis on seniority hierarchy and subordination; inappropriate to query authority knowledge or decisions; knowledge passed on from ancestors and elders orally.</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>29.31</td>
<td>4</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Religious ideology [Ideo]: identifies a religious belief in God, ancestors or spirits or its consequences.</td>
<td>21</td>
<td>16</td>
<td>16</td>
<td>27.59</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Causality and causal attribution [Cas]: notes that success, failure, and other experiences are attributed to annoyed ancestors, evil forces or their agents; not accepting chance occurrences.</td>
<td>23</td>
<td>21</td>
<td>21</td>
<td>32.21</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Procedures for problem solving [Proc]: notes adherence to top-down procedures for problem solving and seeking spiritual guidance via divination, revelation; establishing 'true' causes of experience; knowledge not shared or kept a secret.</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>20.69</td>
<td>7.5</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Categories were adapted from categories developed to summarize main aspects of indigenous world-view in Zimbabwe; in parentheses are the codes used for computer entry. Actual coding proceeded by assigning the category numbers to the text to which they applied.

For each respondent, a code for a category was counted only once even if the code appeared more than once in the text.

Denotes whether or not a category was mentioned in the focus group.
6. Orientation to social change [Soc]: notes conservative attitudes or rejection of new ideas; notes preference for living as in the past; preference for rural–roots; non–responsibility for outcomes and accepting what life provides or withholds; responsibility for innovation.

7. Goal structure [Goa]: notes preference for cooperative existence and activity as opposed to individualistic goals; group completion of tasks; group consensus and unanimity in decision making; acceptance of extended family structure or living with kin; preference for group action; family members contributing to well–being of the individual.

8. Relationship with nature [Nat]: notes a view of nature as sacred and mysterious; attaching human, spiritual and mystical qualities to plants, animals and land forms; taboos and prohibitions related to nature and to body organs; identifies sorcery, magic, and witchcraft or belief in use of magic or charms to enhance skills or use of supernatural forces to harm others.

9. Evaluates negative consequence [Neg]: assesses or gives example of negative or non–complimentary interaction between cultural beliefs, thinking or practice and science education; notes different basis or logic of explanation.

10. Evaluates neutral or positive consequence [Pos]: assesses gives example of indigenous experience or skills complimenting science learning; notes no interaction, traditional beliefs or alternative explanation held alongside or independent of scientific explanation.

| Totals | 224 | 217 | 214 | n/a | n/a | n/a |
persons to strike selected human targets or their properties. Use of magic was mentioned also with reference to enhancing personal success, crop yields, prenatal sex determination, and for harming selected individuals and their families.

In general, the natural environment was considered sacred and mysterious and thus certain taboos existed to prohibit contact with ponds, forests, and mountains where spirits are said to live. Such places could not be accessed and explored unless when for appropriate and sanctioned religious purposes. Taboos also existed to prohibit ordinary use of certain plant or animal species. Taboos related to the environment were mentioned in about 21% of the transcripts. Students from certain ethnic groups could not handle or observe closely certain plants or animals like mice, pigs, owls, millipedes, and others. Nocturnal creatures like hyenas and owls were associated with witchcraft. Many teachers (32.76%) also mentioned taboos related to sexuality and those prohibiting mention of genital organs or sexuality and sex-related issues. Sex-related taboos were believed to lead to shameful and secretive attitudes toward open scientific study of sexuality, sexual reproduction, and other aspects of sex education such as sexually transmitted diseases.

The religious ideology category (3), which occurred in nearly 28% of the text samples, was concerned with spirituality based in the belief in ancestors and spirits (ancestrology); 2 respondents identified traditional religious ideology with fatalism whereby it is held that all events were predetermined by ancestors and were unalterable. According to several respondents, the fear of being haunted by the spirits and ghosts or other religious disdain was ever present so that it was much safer that things and phenomena should remain un-investigated. The religious ideology category was related to category 4 "causality and casual attribution" which was identified in just over 32% of the transcripts. Misfortune, failure, sickness and other life experiences were attributed to spirits or their human agents. Teachers in the present study clearly noted that in indigenous culture, cosmological reasoning dominated thinking about causal relationships. Indeed, it seems that lots of experiences in traditional culture are construed to be symptoms of spiritual actions, moods or need for attention.
Those identifying "reverence for authority" (29.31%) perceived that traditional society was authoritarian. Children were generally not privileged to ask questions or to contribute to family decision making or to disagree to opinions of adults. Questioning was considered a nuisance and disrespectful; children's ideas were generally considered to be inferior and thus according to several respondents students were unable to suggest, criticize or analyze information in science classes. Children acquired an accepting attitude and hence shunned the new and different; there were no rewards for proposing anything different from what elders already 'knew'. Procedures for problem solving (category 5) (20.69%) were supposedly top-down in a linear hierarchy from elders and ancestors to junior members of the family or community. The category "sex or gender bias" occurred also in 20.69% of the text samples. Teachers noted that, in general, females are treated as minors in society and thus they carried an inferiority complex in science classes. Girls did not have the same educational opportunities as boys; they tended to be withdrawn from school or from science classes earlier than boys.

**Focus group data**

The focus group transcript contained reference to all the categories of Table 1 except 7 'goal structure' and thus essentially corroborated the content of written open responses. Figure 1 summarizes the major issues (both positive and negative) raised in this discussion session as noted from the interview transcript. Respondents of this study acknowledged the importance of science, especially its practical applications to national development and to the social well-being and to the health of the community. They felt that, although indigenous culture did not have the term 'science', science or its applications exist in traditional society but that this knowledge is oral. A physics teacher argued the point in this way:

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1 Quotes are as close as possible to what a respondent said with very minor editing, e.g., fillers and pauses are omitted in a few instances.
<table>
<thead>
<tr>
<th><strong>Discussion Themes and Topics</strong></th>
<th><strong>Paraphrased comments and viewpoints</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value of science:</strong></td>
<td>science valued and useful for national development, social and health applications, technology advancement, and providing a base for producing scientific expertise.</td>
</tr>
<tr>
<td><strong>Science in culture:</strong></td>
<td>curriculum must emphasize agricultural applications for the rural sector and industrial applications for the urban sector and raise awareness of science or its applications which exist in traditional society.</td>
</tr>
<tr>
<td><strong>Language in use:</strong></td>
<td>there are problems with exclusive use of English (L–2) and there is need to explain some concepts in vernacular or L–1 language. Some authors address the language problem in texts by using L–1 terminology for certain processes and concepts. Some felt that L–1 distorts acquisition of science terms and vocabulary and pointed out that it has limited vocabulary. Further, some topics are taboo and L1 cannot be used for those topics. Some suggested teacher discretion in using L–2 or L–1 to promote conceptual development.</td>
</tr>
<tr>
<td><strong>Use of examples:</strong></td>
<td>some examples in texts were unfamiliar and far-removed from the pupils' experiences; use hands-on experiences and local materials overcomes problems of language and lack of experience.</td>
</tr>
<tr>
<td><strong>Gender bias:</strong></td>
<td>in society, science subjects are generally labeled masculine subjects; there is low participation and under-representation of females in science and science careers.</td>
</tr>
<tr>
<td><strong>Religious beliefs:</strong></td>
<td>taboos tied to religious beliefs such as fear of skeletons or bones reduced participation in hands-on experiences; there is restricted access, exploration, or investigation of certain landforms, places and plants which are revered and considered sacred; there is strong fear of supernatural forces.</td>
</tr>
<tr>
<td><strong>Preconceptions:</strong></td>
<td>alternative conceptions based in traditional mythology conflict with scientific explanations on the same phenomena; logic and basis of scientific behavior different from that of traditional culture.</td>
</tr>
<tr>
<td><strong>Causal attribution:</strong></td>
<td>causality and logic of explanation dominated by cosmological beliefs; little understood phenomena, events, and misfortune linked to belief in spirits or spiritual agents (witches).</td>
</tr>
<tr>
<td><strong>Orientation to change:</strong></td>
<td>science education should change unfounded beliefs; many felt that religious beliefs or faith are not within the purview of science; it is necessary to distinguish between unfounded beliefs, superstitions and other conjectures based on inadequate knowledge and religious beliefs, faith or belief in God or ancestors; it is OK to hold both the scientific explanation of phenomena and the explanation based on traditional belief; select elements of culture to be transmitted, modified or eliminated.</td>
</tr>
</tbody>
</table>

Figure 1. A summary of themes and issues raised in the focus group interview consisting of 14 randomly selected science teachers on the BEd program.
Sexuality: taboos concerning genitals and sexual reproduction had a negative influence on student response to the concepts involved.

Problem solving: goes beyond finding the physical contingencies and is linked to finding causes of upset social (inter-personal and person-spiritual) relationships.

Limits of science: science has its limitations relative to indigenous culture; science concerned with 'tangible' aspects of experience and cannot resolve issues of a spiritual nature; science may be suspected in society to be a form of witchcraft.

Internalizing science: science is not assimilated and incorporated into the affective and cognitive repertoire of students; people not convinced with scientific explanations because they cannot see the "logic behind the subject"; there was need for an 'indigenized science curriculum'.

Relevance of science: school experience and classroom reality are isolated from real-life social, cultural or family experiences; these experiences were based on different thought, belief, and values and were often non-complimentary.

Parental attitudes: parents are largely traditional, authoritarian, and conservative in outlook; they reject new ideas; parental expectations for open days are social and not education oriented.

Community projects: increase school-community interaction; use community-based projects, e.g., conservation, fowl or rabbit keeping projects; conduct public addresses, demonstrations, displays or open days to show parents the value of science.

Teaching loads: teachers not facilitating parental involvement due to heavy teaching loads, teacher shortage, and lack of time, classroom space, and funds; teachers also lack skills to assess and deal with existence of unfounded beliefs.

Syllabus demands: syllabus emphasizes applications in the community, in industry, and in agriculture; syllabus is too long and science is taught as a theoretical subject.

Examination pressure: examination pressure was identified as a significant problem hampering teachers attention to students cultural backgrounds and their unfounded beliefs and preconceptions.
I think what we are trying to do is to put this science into English and may be into books. Otherwise, science already exists in our culture but the problem is that we do not have any written documents on our side. Otherwise it is there. ... We have simple machines we use in the rural areas say the ones used to lift things. The science is there but we do not have written documentation. (Phy 21)

Respondents expressed divergent views on the use of English (L2) and the mother tongue (L1). The arguments of those favoring English showed that they seemed to view acquisition of science terms and vocabulary as an important outcome of learning science. Some even expressed disbelief that science could be taught in the vernacular and argued that in any case Shona language, for example, had a limited vocabulary. This is exemplified in the response of a physics teacher who said that the use of vernacular should be discouraged beginning in primary school because it causes problems later on.

If teachers start using vernacular in school to explain some of the concepts, then pupils will have a tendency to ask the teacher in vernacular even in form four. And so I would encourage teachers not to use vernacular right from the start so that pupils can acquire the right vocabulary. (Phy 6)

Others underscored the need for teacher discretion in the use of language to promote concept development as illustrated in the following comment by a biology teacher.

No. I think the whole idea of a teaching and learning situation is to achieve excellence. Now the onus is on the teacher to achieve or to try to achieve. And it is also on the teacher's part to use vernacular in so far as it will instill the desired learning result. We are not saying let's entirely lean on vernacular as the medium of discussion but let's use it in so far as it enables us to achieve results. (Bio 14)

The reasons against the use of vernacular languages in science education suggest that many respondents valued acquisition of technical vocabulary as an important outcome of science instruction.

On the interaction of culture and science education, one respondent stated "I think science education sort of frees pupils from cultural and religious prisons" (Bio 14). In general, respondents noted that students already had preconceptions or alternative explanations based in traditional mythology which were in direct conflict with scientific explanations. An example concerning sunken fontanel was given to illustrate the fact that the traditional based explanations were
linked to belief in spirits or their agents (witches). Therefore, the dehydration theory of sunken fontanel was rejected in favor of what a respondent called "a spiritual intrusion into the child" perception of the cause; such alternative conceptions were said to be held widely by the educated as well. Their assessment is that science has not been substantially internalized so that it can be applied to problem situations spontaneously. Conservative parental attitudes, dichotomy between school and cultural experiences, and differences in the logic of traditional thought and behavior and in science were reasons given for lack of lasting adoption of a scientific word-view. Respondents noted also the persistence of misconception of the kind which could easily be disproved by experimental test such as the case in this excerpt:

Bio 4: Actually our discussion reminds me of an experience teaching at [named school] when teaching pollination and crossing in plants. One child stood up, and this child was saying at their home, and now I realize that quite many people believe it, if let's say there is a male paw-paw and female paw-paw. Now, the male on its own will not produce any fruit, so they were saying take some shells or maize cobs and tie them around the stem, then it will bear fruit [laughter]. After teaching the concept on pollination, at the end I realized that quite a number of them were really questioning that kind of practice of tying shells [interjection].

Chem 2: And actually drilling a hole in the stem and placing the cob straight in it, they say that [laughter].

Society did not appreciate the nature and value of science. As a solution, it would be necessary to have community-based projects involving land reclamation and conservation, fowl or rabbit keeping, and to use local materials and resources. Participants generally agreed that at present there was little or not much interaction between the school and the community. Another contribution showed that teachers did not welcome or could not facilitate parental involvement in part because of syllabus length and demands, examination pressure, heavy teaching responsibilities due to teacher shortage, and lack of time, classroom space, and funds.

For this sample of science teachers, cultural beliefs may not be the most critical impediments to acquiring scientific literacy; other antecedent factors, especially the syllabus and examination pressure, constrained efforts in dealing with student held misconceptions. The full text of responses was as follows:
Phy 21: The idea of the syllabuses which hinder the innovativeness of the teacher or the ability to divert from the syllabus. You are just guided by the syllabus, you cannot teach anything outside the syllabus.

Chem 9: And if you teach it [unfounded beliefs] you waste time. It will be like you are wasting precious time. So you are actually in a hurry to finish the syllabus in time so that you get enough time for revision.

Bio 4: We are actually saying we are facing a child coming from a community with a traditional background and we have agreed that to make that child aware of the necessity for scientific knowledge, our teaching must be practical but we are also saying here are long syllabuses and little time on the part of the teacher with exams to come in a few months time. To be more practical is almost impossible, if you do, you do not complete the syllabus. But at the same time that is the activity which would benefit the child when he goes back into the community. So the application of what they learned if we don't carry out practical in our teaching becomes very meaningless.

Chem 13: And also schools expect a pass rather than whether they will use what they learn [interjection: Chem 2: The idea is five O levels! laughter Five O levels!] [interjection].

Chem 4: Or may be a solution could be in lengthening the time, instead of writing the O levels in four years like what is now happening, make them write them say in five years. But again I don't think that this idea will be welcome from some parents. They also want their children to complete these O levels in the shortest possible time especially if they know that their child is capable. So those are the problems we are facing.

Teachers admitted that they lacked the skills required to assess and deal with the existence of unfounded beliefs a situation which was compounded by examination pressure. One respondent noted this problem in the following manner:

Bio 5: The problem here is assessing to see if the kid is convinced that some traditions are wrong and science is correct. To do that you need to, may be, have a long conversation with this child or to have a practical that will dispel all his traditional beliefs. But because of examination pressure you do not have time to really assess whether the student has been truly convinced or whether he has discarded his traditional beliefs. At the same time, the exam will not try and link science and tradition. So you really do not get to notice whether the student is convinced or not. And if the student does not bother, he is going to have two compartments, this is school knowledge that I will use for the exam and he crams the stuff, and this is what I do at home, so he does not relate the two together.

The majority of the participants did not perceive education in general and science education in particular as transmitting Zimbabwe culture. Some participants felt strongly concerning religious aspects of culture and expected the limits of science to be identified. Science was seen as concerned with 'tangible' experience and that it could not resolve issues of a spiritual nature. A biology teacher (Bio 3) said "science is something concrete handiti [is that right?], something which you see and carry out experiments, right! And then there is this belief, I don't see how science can
interfere with my belief, I still have my beliefs. ... So I still have my beliefs, they are there, science is there too". Participants argued that science had its limits and limitations and this observation was used to justify the fact that some teachers held scientific and traditional explanations of phenomena and experience simultaneously. Some felt that science had and should have no influence on their traditional beliefs. Two participants developed this line of thought. One response demonstrated clear reverence of traditional sacred or holy places and plants.

Chem 9: Even now there are certain sacred places or sacred plants which cannot be tempered with. Now they know that they should not use this tree for firewood or you are not supposed to go to this place because if you go there you will get lost. You can' probably remove that kind of fear from some people because it happens. If you want to temper with a certain place or go to a certain mountain— don't go— if you go there are proofs that some people have gone missing in such areas— now with our science I don't see how we can help that. If we are to teach our culture then we should tell our people that don't temper with this plant because it is sacred [interjections: Ah!] ... or don't go to this place because it is sacred. But if we denounce this [interjections] ... we are no longer transmitting our culture.

The second focused on the limits of science in matters of a spiritual nature and also demonstrates a probable commitment to traditional beliefs and religion.

Bio 14: To some extent education is the transmission of culture but it would also be good for science educators to remove the myth surrounding the instruction of science by explaining things to the learners that science has got certain limits. There are some spiritual powers, these powers could be godly or they could be sinister, and science is mostly concerned with tangibles or things that could be investigated but this does not rule out the existence of spiritual forces. Like what he has was saying, that people can go into a mountain and disappear, there are spiritual forces that are sinister which sort of disturb their minds, confuse them, that exist. It's something that cannot be solved by science, they are above science, they transcend science.

A lot of the teachers held both the scientific and traditional explanation on some phenomena despite their obvious contradiction. Respondents in this sample perceived that a distinction must be made between unfounded beliefs, superstitions and other conjectures based on inadequate knowledge, and religious beliefs, faith or belief in God and ancestors. Unfounded beliefs should be changed while religious beliefs or faith are not within the purview of science education. Changing traditional attitudes toward science was seen as a difficult process, even among the participants because of resentment and resistance to change, i.e., conservatism. As one participant put it,
"something had worked for them well in the past so they always stick to that [traditional practice], they feel that if they change then things will not work as they used to" (Phy 21).

Traditional culture based gender stereotypes and deeply entrenched beliefs and taboos, e.g., the fear of skeletons (although this fear is not necessarily restricted to non-western societies) and their association with spirits made it difficult for a traditionalist to appreciate science. One contributor stated that science in fact was considered in traditional circles to be sacred and a form of witchcraft. A female biology teacher (Bio 3) provided the following testimony.

Bio 3: Now at the school where I was teaching we had lots of specimens in the lab, different sizes of snakes, skeletons, and the like. So there is this certain old man, a general hand, he was wondering how I could survive in such an environment [laughter] being a lady for that matter. Now, if you take such an individual to try and explain science to him, I think even if you try by all means to explain but still deep inside, he will be wondering 'so why you need the snakes?'... [interjection: Chem 2: And he will say that is witchcraft. Science is witchcraft]... .

Similar issues as raised by the BEd science teachers were raised by heads of science departments in six teachers' colleges with reference to their preservice science teachers. The science teacher educators corroborated the perception that indigenous culture based beliefs or explanations could be carried alongside or independently of the scientific explanation. Five of 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.

Discussion

Tesch (1990) identified the last stage in content analysis as synthesis in which the overall meaning and interpretation of the data are given. The rest of this paper discusses some of the issues raised by science teachers in contributing to the written question and in responses to questions in the focus group interview. This study sought to describe science teachers' experience, observations, and knowledge concerning the interaction of indigenous culture with science education in Zimbabwe. An overwhelming majority (94.83%) of the sample identified at least an aspect of indigenous culture
which related to science education negatively. Their responses illustrated that their experience and belief was that indigenous experience and the basis or logic of explaining or interpreting that experience was different and independent of scientific explanation. If the experience of these teachers is anything to go by, it can be concluded that a scientific perception of reality is not part of the everyday cognitive and affective repertoire of indigenous students and in some cases those of science teachers in Zimbabwe. In fact, several others have also noted this 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). However, as Yakubu (1994) notes:

this should not be construed to suggest that science and technology are incomprehensible to people in the developing countries. The suggestion is that spontaneous application of the scientific spirit learnt through the western form of education is lacking. There seem to be something which inhibits the spontaneous application of scientific ideas in problem situations. 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)

Acknowledgment of the value of science

In this study science teachers acknowledged the value of science in Zimbabwe and in particular respondents in the focus group and science lecturers in the teachers colleges concurred that science significantly informed and improved one's view of experiences. 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, as noted above, the reality was that scientific ways of thinking had not become a spontaneous tool to view and explain experiences; and thus Cobem (1993) noted 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" (p. 1). Issues concerning indigenous culture including traditional world-view were raised by teachers in this study including gender bias, reverence for authority, religious ideology, orientation to change, orientation to problem solving, beliefs concerning the relationship with the natural environment, and causality and casual
attribution. These were areas of belief and knowledge which students acquired from indigenous culture and which interacted in a manner non-complimentary with goals and outcomes of science education. All the issues require the attention of science educators for meaningful and lasting adoption of the scientific world-view to take place.

Gender issues, sexuality and sex education

Gender issues in science education in Zimbabwe require considerable attention, immediately. About 21% of the respondents of this study noted, gender bias against females is deeply ingrained in traditional culture. This usually results from the emphasis to sex role differentiation as noted in several sources (Aschwanden, 1982; Bourdillon, 1987; Bozongwana, 1983; Gelfand, 1973). This is, typically, to ensure that children grow naturally into their predestined roles and also to make "each child look forward with pleasure to its allotted task" (Aschwanden, 1982; p. 44). The consequences of this 'pre-destiny' idea were well noted in this study by a female teacher who stated:

In the traditional Shona culture especially Manyika where I belong, girls have always been treated as minors in society, in fact the whole female gender. The females have actually accepted this. But science is a challenging subject requiring one being industrious and confident. Girls seem to carry with them this inferiority complex into the classroom. They fail to tackle the subject confidently and to explore into the unknown areas of scientific investigation. They are reserved and tend to withdraw and hence adoption of concepts is hampered. In fact many withdraw from this field and choose to take the arts field. (Chem 5)

Sex role type education and gender differentiation in traditional society have serious undesirable effects on female attitudes towards science and science-related careers as a recent study in Nigeria showed (Jegede & Okebukola, 1992). Jegede and Okebukola report that science is not considered a "woman subject", rather, the "study of languages and social sciences are often regarded as being the center of attraction for female students" (p. 643) a finding corroborated by teachers in the present sample. Further, they noted:

boys are allowed to undertake activities which can promote better perception of science as a career opportunity. They are allowed to climb trees, set traps, go fishing, dismantle mechanical objects, probe valleys, caves and hills, chase butterflies, build models, and explore the environment. ... Girls, on the other hand, are prevented from engaging in risk-
prone activities and exploring the environment in the vigorous manner that boys are apt to do. (Jegede & Okebukola, 1992; p. 643)

The tragic perception among teachers in the present study is that girls grow to accept this gender bias which if not reversed, in the long-term will continue to create a situation in which females are underprivileged and under-represented in science-related careers. As one of the teachers in this study implored, it is females who are more likely to spur scientific literacy in the community if only because of the greater availability of females in the home.

Also in our culture girls are disadvantaged; they do not have the same opportunities as boys to learn any subject because they are often removed from or dropout from school before 'O' Level yet they are the ones who have a lot of influence on the children when they become mothers. If they were afforded the same opportunities to learn science they would be able to teach the children simple scientific facts at home and thus transform society into one that is free from many fears and mysteries of nature. (Bio 17)

This study found also that a substantial number of teachers identified sex education, especially issues concerning sexuality and sex organs, as taboo and sacred in many communities in Zimbabwe. Sex-related issues are not supposed to be talked about openly in mixed classes. The consequence is that students and teachers are reportedly shy when topics concerning sexuality, sexual reproduction, and sexually transmitted diseases are introduced thus inhibiting the learning of required concepts. Obviously one cannot overemphasize the need for accurate knowledge and awareness of matters concerning sexuality and the sexual reproductive system especially with the scourge of AIDS and other sexually transmitted diseases, teen pregnancies, and other sex-related social issues. When certain topics, e.g., abortion, AIDS, etc., are considered taboo in the community, science teachers often do not teach them (McGinnis, 1992) and thus children lose an opportunity to gain knowledge which might make a difference at some point in their lives. The puritan attitudes towards sex education among the people of Zimbabwe ignore the reality of the seriousness of problems created by uninformed sexual activity and behavior.

Reverence for authority

In African societies in general, there is reverence for authority figures or adults implying that the locus of control and authoritative knowledge lies with adults (Jegede & Okebukola, 1992).
Authority figures are perceived as credible and infallible sources of information and solutions to problems. It is virtually inappropriate for children to query knowledge or decisions of adults as one teacher in the study explained:

Generally pupils are not free to contribute their ideas especially through questions and disagreements because they think it is an element of being disrespectful. This emanates from the fact that Shona culture people believe in young people not contributing to important family decisions giving the false idea that elders are always correct. (Chem 13)

A biology teacher in this study captured the consequence of the authoritarian character of indigenous culture in the following terms:

In addition to this our Shona culture teaches pupils things which they are required to accept without question. This is unlike science where pupils must be respected in terms of what they say. The children’s ideas are considered inferior and looked at with contempt because a child is used to this way of treatment. She/he finds it difficult to suggest, criticize and analyze things to come up with reality. (Bio 13)

Jegede and Okebukola (1992) note that authoritarianism limits the extent to which students have a mind of their own since elders serve as the locus of authoritative knowledge. 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 other comparable contexts (McKinley, et al., 1992; Prophet, 1990). In this study, a physics teacher made the following contribution which also depicts a general characteristic of the Shona depicted in books (Gelfand, 1965 & 1973):

One negative influence that Shona traditional culture has on indigenous Zimbabwean students' learning and adoption of science is the killing of thinking and creativity. Generally in Shona tradition, children are not encouraged to labor ideas or show practices that are considered by the elders as unheard of. As a result students concentrate on the accepted and shun the new and different which is so vital in broadcasting the horizons of scientific knowledge. Students are not therefore ready to display the creativity as they know that there are no rewards for proposing something unheard of before. The great respect Shona students have for the opinions of other people acts as a means of self-censorship and students do not venture into new and controversial field. (Phy 17)

Further, there are no rewards for children who are inquisitive as noted by a physics teacher who wrote that

parents often reward children who are quiet, who do not bother them with questions. Those children who bother their parents with a lot of questions are labeled to be nuisances and not respectful. When these children go to schools they are afraid to ask questions. Their participation in class is very low and as a result their performance is also low. (Phy 27)
Problem solving, decision making, and logic of explanation

Further implications of the authoritarian character of indigenous culture is that problem
solving has to follow a fixed code of manners and adhering strictly to the "correct" procedures laid
down by tradition (Gelfand 1965). Consequently, the process of problem solving and other
behaviors among traditionalists is often in a linear hierarchy from the top (ancestors and elders) to
the bottom (junior members of the family or community). In fact it is said that all activities have a
"correct" way by which they must be completed and thus such an attitude could stifle
experimentation and innovation. This often has a consequence that students hold an expectation
that problem solving is finding out information that is already known and must be proved. Along
the same lines, in an interview, a science teacher educator commented on student teachers' ability
and willingness to conduct original experiments as follows.

I don't think they would attempt that [doing a non-textbook experiment], the thing really
is that we have almost got most of the things written in books. I have had students come to
me and say 'this experiment you made us do in chemistry, it's not found anywhere in the
textbooks in the library. Do you have any textbook on it?'. 'No! All I wanted you to do is to
observe and record what you observe and then carry out the calculations' and that sort of
thing. They are not particularly happy, we have been drilled to perhaps believe that
everything should be from a textbook. (Mr. Matina, personal communication, April 27, 1994)

Further, indigenous science students often fail to see the tentative nature of solutions to problems or
to knowledge as Shrigley (1971) observed with Nigerian preservice teachers. For example he
described his experience of the students reaction to the tentativeness of scientific knowledge as
follows:

Students were inclined to view science as final and fixed. Some of the most uneasy moments
developed when dealing with problems having only tentative answers. In desperation, one
keenly-interested science student stood beside his desk and in typical African politeness
asked, "Why don't you teach only what scientists are sure of?". It is my conviction that
many traditional explanations to natural phenomena are, in part at least, the result of this
uneasiness sensed by the African when a phenomenon goes unexplained. Even a tongue-in-
cheek explanation seems better than no explanation at all. (Shrigley, 1971; pp. 211-212)

This quote also demonstrates a point raised by teachers in this study. There is a belief in
traditional society that every experience has a cause or an explanation and usually this
explanation is of a cosmological nature which often accounts for lack of experimentation or for
attitudes which support it (Yakubu, 1994). When the reasoning pattern is predominantly cosmological, experiences are explained in terms of the moods and actions of spirits and supernatural forces which unfortunately are not susceptible to experimentation or to tests. Acceptance of the actions of these forces without question also explains the general lack of critical questioning as noted by informants in this study. As an example, one of the respondents cited the belief concerning witchcraft:

in our communal areas some elders boast of flying to any corner of the country using musero or rusero [a dish like utensil]. This musero without having fuel, rotors, and even wings can easily be used as an aircraft. A stipulated number of passengers are known to be carried just as modern aircraft do today. What explanation can be given to this? Only the elders and the enthusiastic pro-witchcraft can. So this is one of the predicaments one can always find himself in when teaching science. Some traditionalist can actually come to the extent of sending an animal (of course wild) to go and talk of his problems or needs to a certain family. This of course is called chikwambo. (Phy 16)

As responses from some teachers in this study indicate, certain experiences which would seem logical to explain on the basis of scientific explanations are not so explicable. There is an attendant danger of the scientific world-view being perceived as weak because a faulty impression is created that science can be applied to all situations including supernatural belief.

Difficult problems are often not tackled and when they are tackled, often they are approached from a cosmological perspective. For example, problem-solving in traditional culture may typically involve finding out absolute solutions via processes which might include revelation, dreaming, and/or divination. These processes try to establish and verify the social and spiritual relationships that may be anomalous and which must be rectified and thus a diviner might be involved. A diviner's role involves making contact, receiving, and communicating messages to and from the spirit world to human beings. He or she therefore enables people to be given knowledge of things that would otherwise be difficult or impossible to know (Mbiti, 1990; p. 167). According to Kirby (1986) diviners "increase certainty and predictability, give explanations to misfortune and put order back to men's lives by prescribing correctives to disruption" (p. 105). However, if cultural methods of problem solving, of which they are many, are not placed in their proper situational
context, they could be inhibiting in science education. The experimental approach involving manipulation and control of variables is often a very difficult process for indigenous students to appreciate as lecturers in the teachers' colleges testified. For example, divination is supposed to provide absolute, accurate, and unquestionable knowledge about the cause and about solutions to problems unlike in science where knowledge or processes leading to that knowledge are tentative, amoral, and developmental. Divination as Kirby explains "offers the means of knowing what cannot be experienced empirically through the senses or deduced by logic" (Kirby, 1986; p. 105) and thus fundamentally differs from the scientific basis of problem solving. MacGaffey (1986) speculates that diviners or healers may even be regarded something like scientists since their role includes attempts to explain some part of experienced reality. The belief that no matter what one does to the physical or material contingencies and objects, other more fundamental causes of the problem exist can have undesirable ramifications on indigenous students ability to acquire an accurate conception of the nature of science and the role of experimentation. MacGaffey (1986) notes that the general neglect to explore physical and material contingencies has a debilitating effect on Africans' ability to pursue science to their full potential.

The logic to traditional approaches to problems and to explaining experience can be understood when the fact that, in African cosmology, humans are considered to be at the center of the universe (Mbiti, 1990 & 1991; Ogunniyi, 1988; MacGaffey, 1986; Gelfand, 1965 & 1973). Stable and normal relationships with other human beings and with the spirits is necessary for living in an indigenous society. For example in Zimbabwe, the centrality of the human being and attention to normal existence among kin and spirits is said to be "with an almost neglect of the material aspects of life" (Gelfand, 1973; p. 198) especially among the Shona. Among Zimbabwean traditionalists, learning to behave well makes for a normal human being and doing otherwise makes for a human animal (Aschwanden, 1982). MacGaffey (1986) writing on the people of Zaire even speculated that this preoccupation with sustaining relationships with kin and others and with the spirits literally blocks the potential of the African to pursue natural science or to project their social life into the
material world. Science education has got a task to ensure that indigenous students understand the ultimate purpose of experimenting with materials and objects as well as how science relates to society and their social lives.

**Causality and causal attribution**

A correct perception of cause-effect relationships has been said to denote scientific understanding (Coburn, 1993; Murphee, 1969). In traditional environments, cause-effect relationships are typically approached from a cosmological perspective as demonstrated by explanations given by teachers in this study. For unusual experiences, "true" underlying causes other than the immediately observable physical causes are believed to exist. Accidental or chance occurrences like most other unusual experiences have higher level causes which must be explored. One expert illustrated the pervasiveness of the belief with the Shona saying *chiripo chariuraya, zizi harifi nemhepo* [there must be something which killed the owl, air cannot kill it] meaning that the underlying causes exist (T. Shoko, personal communication, April 25, 1994). For example, sickness and misfortune are believed to have ordinary physical causes as well as spiritual or psychological causes. The latter is linked to a belief that illness and anything out of the ordinary is caused by angered spirits, by witchcraft or by sorcery as demonstrated in a preceding section with reference to the spiritual intrusion theory versus the dehydration theory of sunken fontanel. These utilize supernatural forces in order to disrupt the existing social relationships, creating strain in the life of traditionalists, which must be resolved to provide social and psychological relief. Any persistent trouble or anxiety is "interpreted in terms of this relationship [with spirits] and in terms of tensions and ill-will within the local community" (M. Bourdillon, 1987; p. 151). As Bourdillon further elaborates:

> Until the ultimate cause of the trouble is discovered and appeased or overcome, there remains the frightening possibility of further trouble, and it is hopeless to expect complete relief from the present affliction. According to Shona belief, western medicinal treatment can only alleviate the symptoms of abnormal illness, or at best it can cure the present illness, but it remains useless against the original cause of an illness which can always strike again. (M. Bourdillon, 1987; p. 149)
According to Bourdillon (1987), natural causes of events and phenomena are accepted insofar as these causes can answer "how" something happens but do not accept them to explain "why" to this particular person and why at this time and place. The explanation why is cosmological and this differs from the emphasis in the use of existing theoretical knowledge in science to explain how things happen. As an example Bourdillon (1987) cites the case where a man drowns attempting to cross a swollen river; he says of this incident "the natural cause of death was obvious, but his relatives still wanted to know what had blinded him to the danger..." (p. 173) which begs for the spiritual explanation. Accidents or chance occurrences are not readily accepted outside of their cosmological context. This logic of thinking extends to perception of disease causation where, even though the germ theory may be accepted, cosmological causes are sought. As one chemistry teacher in this study explained

Also certain illnesses are not readily accepted to be caused by bacteria, viruses etc. People go to witch-doctors to find out causes of illnesses only to be told about problem neighbors who would have cast evil spirits upon the ill. This pupils find difficult to discard even when teachers explain scientifically how they are caused. (Chem 10)

MacGaffey (1986) ventured to suggest that in traditional cultures the distinction between the mystical from the empirical is fuzzy. In a traditional culture 'mythical' thinking replaces conceptual thinking and therefore it is imperative that indigenous students acquire an accurate understanding of the nature of science as well as of their own traditional world-view. This calls for a comparative approach whereby the scientific world-view is compared to the traditional world-view to illustrate the multiplicity of perceptions of reality and their relative limitations (Ogawa, 1986; Ogunniyi, 1988; Cobern, 1991 & 1993; Yakubu, 1994).

**View of nature**

The majority of teachers identified an aspect associated with the category of beliefs 'relationship with nature'. Their contributions suggest that nature and the natural environment are viewed as superstitious and supernatural which may interfere with attempts to develop scientific understanding of the relationships with the natural world. The most frequently cited example of
indigenous belief or practice was the use of a natural force such as lightning by malevolent people to attack select human targets and their properties (53.45%). The lightning phenomena was perceived as something which humans made and used malevolently; when it struck it is believed to leave some eggs for the reason which it will strike a second time to retrieve them. Others suggested that a dove-like lightning bird actually laid the eggs at the time of a lightning strike. Wearing red clothes made one even more susceptible to lightning strikes. Teachers in the study explained that the logic by which this powerful natural phenomena is experienced and perceived clearly differs from the scientific explanation and thus it becomes difficult for people to understand the rationale for using lightning conductors and to take other measures to reduce the likelihood of lightning strikes. The consequence of the belief is also captured by a chemistry teachers' response which in part read:

The question of whether human beings have an ability to manipulate nature has a significance in the teaching of lightning to form 3 and 4 students. Most pupils tend to think that lightning is caused by human beings instead of a natural phenomenon. There is no openness about this issue which makes it very difficult to convince pupils on this issue. Most students even went to an extent of mentioning individuals in their communities [who could make or control lightning] but I naturally found that this was sensitive issue and I intelligently stopped the debate. (Chem 22)

Another teacher in this study wrote that "in one particular science lesson pupils shuddered and pleaded that I stop explaining how lightning occurs when it was about to rain with lightning moments from occurring. This they believed would make our class a potential target" (Chem 10). The fact of the matter is that indigenous students acquire strongly held alternative conceptions to explain phenomena and these preconceptions can be severely constraining to the process of acquiring scientific conceptions.

Further, natural forces or other natural things associated with the spirits are never talked about for fear that the individual concerned will be struck by the force concerned. In general, nature including the natural environment is considered sacred and mysterious being the home of spirits or things in them being provided by the spirits or being sacred. Gelfand (1973) made a claim, which may no longer be valid, that nature is generally revered to the extent that people do not marvel at
its beauty openly; he says "the Shona avoid expressing in words 'admiration of a beautiful scene' for fear of invoking the anger of some alien spirit by judging something about which they know nothing" (Gelfand, 1973; p. 146). This, if true, could have serious limitations on the extent to which students can explore and inquire about the natural environment. A physics teacher cited an example of taboo belief which could limit experiences of some students in science education:

Some superstitious beliefs affect the progress of science conceptualization because students at times shun 'hands-on' methods because in our Shona culture they are sometimes told of holding some small animals or certain leaves as taboo. Students do not normally like to get closer to a chameleon, millipedes or even handling tadpoles or frogs. Our culture tends to protect our children from handling untamed species for example an owl. An owl in our culture is associated with witchcraft, so bringing an owl to a lesson for the study of birds species is taboo to our children. When studying about teeth, skulls, etc., our children are scared to hold a person's skull because they are afraid of being haunted by the spirit of the dead person. (Phy 12)

These restrictions in handling certain species is a safety precaution against serious injury or even death which, unfortunately, when connected to other forms of belief can lead to science being misconstrued as a form of witchcraft. This perception is in part because people practicing science handle objects that are considered taboo in traditional culture. Science is sometimes also perceived as sacred in part because when its practitioners violate a well believed taboo nothing seems to befall them as would be expected in the case of ordinary members of the community. In other comparable cultural environments, science is reportedly perceived as "weird and special, requiring magical and superhuman explanations" (Jegede & Okebukola, 1992; p. 639).

Language, examples, and use of local examples

A concern arising mainly in the focus group interview was that the exclusive use of the official language English presented some problems to students in some topics. The teachers were divided on whether vernacular languages could be effectively used to teach science and some felt it could possibly not be used to teach topics such as 'reproduction' which were considered taboo in the local communities. Further, some teachers presented the argument that vernacular languages lacked technical vocabulary used in science and thus students would be disadvantaged when it came to examinations. Similar and other reasons against the use of vernacular are illustrated in the
articles by Prophet (1990) and McKinley, et al. (1992). Another line of argument raised issues of the type and relevance of examples used to illustrate science concepts. Some examples were said to be "far-fetched" relative to experiences of the students. A biology teacher also raised the issue which can be linked to the misconception of science as a technology:

Also pupils from rural areas do not come into the classroom with experiences that they can relate to science. For most of them science exists as a subject that must be passed at 'O' level only. Technology has not been adapted to meet their immediate needs. They have little experiences in their live where they can link science to their own home environment. (Bio 17)

Another teacher perceived that there were experiences in the cultural environment which could support science education, a point which is well worth exploring further:

But on the other hand some aspects in our culture accelerate the conceptualization of some concepts because children always see the things before even doing the practicals in the laboratory. Children already have some sort of experience on some practicals, for example, keeping of rabbits, chickens, comprising foot prints of various animals, studying plant species like the musasa, mopane, etc. Children already know the species already. (Phy 12)

Cooperative goal structure

A handful of respondents of this study identified only the "cooperative goal structure" as having positive implications for science education. Traditional culture emphasizes cooperation and sharing rather than individualism and competition. Mbiti (1990) observes that:

... the individual does not and cannot exist alone except corporately. He owes his existence to other people, including those of past generations and his contemporaries. He is simply part of the whole. The community must therefore make, create or produce the individual: for the individual depends on the corporate group. (p. 106)

Science education in Zimbabwe could probably benefit from the cooperative disposition of indigenous culture whereby students can be organized to participate in group tasks, projects, and experiments. Previous studies have attested to this need to capture the cooperative spirit in comparable cultures (Jegede & Okebukola, 1992; Prophet, 1990; McKinley, et al., 1992). Appropriate training and support for the cooperative group effort in science could in fact alleviate the pressure on the limited resources in science education.
Implications

Overall, science teachers in this study provided substantive information on dimensions of indigenous culture and world-view in Zimbabwe which interacted with science education. While on average the number of teachers identifying a particular category rarely exceeded 30%, nearly all who did gave a negative consequence of a specific cultural belief, practice, or dimension. The low percentage is assumed to be explicable because of the open-ended nature of the responses; if a structured approach whereby dimensions of culture are presented, there likely would be a higher percentage of respondents evaluating or reporting incidence of their negative influence in science education. The fact that they are able to identify these dimensions as problematic testifies on the practical significance a better understanding of indigenous culture relative to scientific culture is.

Ogawa (1986) and Ogunniyi (1988) have observed that in non-western cultures, science represents a second culture for indigenous students. In this study, almost 95% of the teachers evaluated the influence of categories of indigenous culture in science education as negative. Several of the participants explained that the logic of explanation in indigenous culture was different from science education and thus our sample of teachers was aware of some of the dimensions of indigenous culture which would have to be seriously understood for meaningful adoption of science and its values. The two cultures represent two different but logical systems of belief and explaining experiences in the world.

Our sample seemed to be disillusioned and even dismayed that they dealt with two incompatible views of the world but the majority perceived that the indigenous cultural logic and belief system had to be supplanted by scientific reasoning. On the other hand, it was starkly clear that assimilation of the scientific perception of reality was never complete. It would be fruitful if teachers and science educators strive systematically to acquire a scientific understanding of the nature of indigenous culture just as much as they systematically grapple to understand the nature of science and scientific knowledge. As is clearly articulated in the literature cited in the background to this study, a scientific perception of reality is just but one way to view and understand the
physical and social environment and thus a comparative approach may be worthwhile (Horton, 1971 & 1982; Krugly-Smolska, 1990; Ogawa, 1986; Ogunniyi, 1986 & 1988; Yakubu, 1994). For the indigenous student, an indigenous view of the universe is a more reasonable, accessible, and a commonsense means by which experience is perceived and interpreted or explained.

Teachers in this study were also aware that a scientific perception of reality can be acquired provided that sufficient attention is paid to the use of everyday situations and practical applications in science education. They proposed a community based approach to science education where-by real community projects involving the problems and concerns of the community such as livestock production and land use and management were carried out. Similarly the process of scientific problem solving should be applied to real-life situations so that the processes of problem formulation, hypothesizing, experimental design and variable control and manipulation, and using evidence to reach conclusions can have real-time meaning.

Further, indigenous culture is not without experiences which could be explained scientifically as demonstrated in a recent doctoral dissertation (Muchena, 1990). Such traditional practices and processes should be studied to establish which aspects can be viewed and explained from a scientific perspective. In other words we need to address the serious question concerning selection of items of content from Zimbabwean traditional culture (T. Bourdillon, 1977). In my opinion, the dichotomy between school and indigenous home experience leads to education in Zimbabwe being treated as an event rather than a process whereby indigenous parents perceive "your school knowledge" relevant for examinations and "our knowledge and ways of doing things" relevant to practical real-life situations. School knowledge is in danger of continuing to be perceived as external and theoretical knowledge when compared to what is needed to cope with the realities of everyday living in a predominantly traditional culture of Zimbabwe. As Thomas Bourdillon (1977) suggested, schools need to be aware of their cultural role and therefore must make students aware of the discontinuities between what they learn in school and their experience in the home. New forms of knowledge, in this case science, must be introduced wherever possible, to "build
on what the child has already encountered, and ways which will also reveal the differences in viewpoint between western scientific thinking and traditional thinking" (Bourdillon, 1977; p. 32). One of the advantages of this approach of taking into account students cultures is motivational and another is that a conducive environment is generated whereby the school curriculum is perceived as relevant (McKinley, et al., 1992). A systemic approach to articulating and integrating home and school culture is unquestionably desirable. Since the organization of the education system is centralized, a systemic approach should also address the concerns of teachers pertaining to syllabus length, examination pressure, and teacher shortage which they say militate against any substantive efforts to address students' misconceptions.

Conclusion

This study demonstrated science teachers' perceptions and awareness of the serious differences and contradictions between the world-view in their socio-cultural environment and the world-view to be developed in science education. The significance of this study is that it encourages teachers and teacher educators to pay attention to students' ways of thinking and especially to emphasize that there are different ways of thinking represented, first, by their own cultural world-view and, second, by science. Clearly, issues raised by teachers in this study suggest the need for careful thought and reflection in the conduct of science education in a predominantly traditional culture. Scientists, technologists, teachers, teacher educators, and other professionals need to have a deeper understanding of the indigenous traditional culture and cannot continue to ignore this area of knowledge which obviously may be non-complimentary, debilitating, and frustrating to their efforts. Cobern (1991) perceives that culture is a system of meaning and significance (p. 8) and thus it provides a context on which all other subsequent learning is to take place. Research is needed therefore to better understand and to apply knowledge of cultural context including what students and teachers believe about their physical and social world. Future research should attempt to understand the ways and extent learning outcomes in science education are influenced by indigenous cultural values and beliefs and on how science education can be
integrated with traditional beliefs students hold (Yakubu, 1994). This study barely scratched the surface!

References


Appendix I

1. How do you view the role of science in the school curriculum? [How do you view the relationship of science to other curriculum subjects?]

2. Do you think that science, its facts, methods, and values should be embraced or not embraced in Zimbabwe society? [What does it matter that in traditional society the word 'science' does not exist?]

3. What do you perceive as the consequences to science education of aspects of indigenous culture such as orientation towards traditionalist religious beliefs, superstitions, sex stereotyping, and the relationship between the young and elders?

4. Giving examples to illustrate, how has being raised in indigenous culture affected or influenced your perceptions of science?

5. Think back to your teaching situation. What specific traditional customs, values, or beliefs influenced the way your students learned science? [How did you deal with these customs, values or beliefs to help your students learn science better?]

6. What suggestions can you make to science educators for dealing with specific aspects of traditional culture in the science curriculum in Zimbabwe?

7. Do you think the goal of scientific and technological literacy is relevant, realistic, and achievable in Zimbabwe or not?

8. What is the greatest challenge in teaching science to indigenous students in Zimbabwe?

9. What could you say are the reasons why science, its methods, and values are not widely adopted and used in Zimbabwe society?

10. Do you have any additional comments, reflections, or experiences regarding the interaction of our indigenous culture and science education?

Figure 1. Interview schedule used as a questioning route in the focus group session
CHAPTER V. RELATIONSHIP BETWEEN SECONDARY SCIENCE TEACHERS' ORIENTATION TO TRADITIONAL CULTURE IN ZIMBABWE AND BELIEFS CONCERNING SCIENCE INSTRUCTIONAL IDEOLOGY

A paper to be submitted to the Journal of Research in Science Teaching

Overson Shumba

Abstract

This paper reports on findings of a study which measured secondary science teachers' level of commitment to traditional culture in Zimbabwe and explored how this orientation is related to their beliefs concerning science instructional ideology. The sample used in the study consisted of 63 teachers reading for the Bachelor of Education degree at the University of Zimbabwe. The science teachers were found to have a relatively lower commitment to traditional values and beliefs than predicted. Their scores of commitment to indigenous culture were positively and significantly correlated to traditional non-inquiry ideology preference scores but not to inquiry instructional ideology preference scores. Preference for traditional non-inquiry ideology was interpreted to be compatible with authoritarian tendencies in traditional culture. Implications of the findings are discussed relative to conceptions of the nature of science and scientific knowledge and relative to cognizance of the interactions of science, technology, and society found with the same sample of teachers.

Background

The current five year national development plan in Zimbabwe states that "development of science and technology is Zimbabwe's long term and most important strategy for economic and social development" (Government of Zimbabwe, 1991; p. 84). Unfortunately, the scientific world-view assumed in these plans is a phenomenon that is neither substantially congruent with the
predominantly traditional world-view in Zimbabwean culture nor is it significantly widespread. Nelson (1982) and M. Bourdillon (1987) for example report that the majority of Zimbabweans, including the educated, hold or at least fall-back in times of crises to beliefs and practices they acquired from their indigenous African culture. The American Heritage Dictionary defines world-view as 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 (p. 2058). World-views are fairly stable and consistent values, beliefs, and frames of reference about the universe and therefore it stands to reason that one world-view cannot easily supplant another (Cobern, 1993). This article seeks to give, first, the background to some dimensions of indigenous culture and world-view in Zimbabwe which are likely to have implications to science education. Second, the article seeks to review research on socio-cultural variables and their connection to science teacher education. Finally, it presents the results of a study which measured indigenous science teachers' orientation to indigenous culture and to instructional ideology.

Overview of indigenous culture of Zimbabwe

While Zimbabwean culture is multiethnic, multilingual, and multi-cultural the indigenous world-view based in traditional custom and lifestyles of Shona and Ndebele ethnic groups is quite pervasive especially in rural areas where at least 80% of the people live. Western culture is more pronounced in urban centers. Although many Zimbabweans have adopted western material values, Chirungu, they are still closely attached to their moral and spiritual past, Chivanhu. The Shona and Ndebele ethnic groups make up over 90% of the population (Nelson, 1982). Figure 1 delineates some dimensions of traditional culture in Zimbabwe.

Traditional culture is sustained by observing oral traditions which are strictly enforced by adult members of society. Normal behavior requires observing and respecting the linear hierarchy in which younger members of the community including females and children are at the nadir and thus have lesser privilege to query, criticize, and contribute to decision making (Gelfand, 1965 & 1973; Aschwanden, 1982; M. Bourdillon, 1987). Questioning authority is often regarded as
Dimensions of traditional culture

1. Sex role type education: belief that social roles should be delineated by gender; inequality between sexes; treatment of females as minors; male dominance.

2. Reverence for authority figures: belief that locus of control and wisdom lie with elders; authoritarianism; emphasis on linear seniority hierarchy and subordination; inappropriate to query authority knowledge or decisions; knowledge passed on from ancestors and elders orally.

3. Religious ideology: spirituality based on belief in God, ancestors and spirits as determinants of fortune, misfortune, or other experiences; focus on sustaining normal social and spiritual relationships with kin and spirits; humans at center of universe.

4. Causality and causal attribution: attributing success and failure to human or spiritual agents; belief in mystical or teleological causes of phenomena; 'true' causes as evil forces, witchcraft and magic; not accepting chance occurrences.

5. Procedures for problem solving: adherence to 'traditional' top-down problem-solving procedures; problem solving as a group function; establishing mystical causes or explanation for observed reality via divination; establishing 'true' causes of experience; knowledge not shared or kept a secret.

6. Orientation to social change: preference for living as in the past, Chinyakare; conservative attitudes and strict adherence to traditional values; preference for rural-roots; accepting what life provides or withholds; non-responsibility for outcomes and innovation; normal behavior based on custom and tradition.

7. Family and goal structure: preference for cooperative existence and activity as opposed to individualistic goals; group completion of tasks; group consensus and unanimity in decision making; acceptance of extended family structure or living with kin; family members contributing to well-being of the individual.

8. Relationship with nature: view of nature as sacred and mysterious; attaching human, spiritual and mystical qualities to plants, animals and land forms; taboos and prohibitions related to natural environment; restricting and regulating use of resources; nature as both benevolent and malevolent.

9. Sorcery, magic, and witchcraft: use of magic or charms to enhance skills including farming; ailments or misfortune blamed on people using magic; use of supernatural powers or forces to harm others; paradigm for anti-social behavior.

Figure 1. Some categories of indigenous traditional culture in Zimbabwe
disrespectful and children who are inquisitive are often chided for being too clever, i.e., *akangwarisa*. Knowledge and wisdom are passed from elders to the next generation orally via mythology and folk-tales. Problem solving is from top-down, following the "correct" procedures established by tradition and enforced by elders; in the top-down hierarchy, elders are supposed to be wiser and more knowledgeable than junior members of society.

Normal social relationships must be sustained and indeed the whole philosophy of traditionalists revolves around the human being; thus observations and experiences are typically perceived and interpreted from a personalized and subjective point of view (Gelfand, 1973). Typically, upset social or spiritual relationships provide a psychologically satisfying explanation of unusual trends and misfortune; these mystical explanations supersede the physical contingencies which normally account for "how" things happen or happened. Although natural physical causes are accepted to explain some experiences, there is always a belief in other underlying causes of a mystical nature which are based on belief in spirits or their agents (Bourdillon, 1987). Relatively speaking, cosmological reasoning dominates thinking about cause leaving relatively little room exists for experimentation; spirits, witches or jealous and malevolent neighbors or relatives are causes of misfortune and ill-will and these are not empirically testable. Mystical explanations provide also a basis for understanding the nature of spiritual relationships and indeed it has been said that maintaining harmonious social relationships is considerably more important than materialism (Gelfand, 1973; Bourdillon, 1987) or preoccupation with understanding relationships among objects (MacGaffey, 1986). Chance occurrence and probability are not tolerable, certainty and predictability are preferred (Gelfand, 1965). A fuller description of the traditional culture under review can be found in Shumba (1994).

These observations and issues define the indigenous world-view which represents the way reality is experienced, interpreted, and perceived. The preceding overview is an attempt to show that the premises of the scientific world-view differ from the premises of traditional world-view, yet both represent legitimate ways of interpreting experience (Ogunniyi, 1988; Yakubu, 1994). The
basis on which experiences are perceived and interpreted in indigenous culture is different from the way indigenous students are taught to perceive and interpret the same experiences in science. Dealing with the apparent contradictions should be a concern for science educators working especially in traditional non-western contexts. An immediate concern should be to evaluate the extent to which science teachers adhere to specific dimensions of indigenous world-view and how these might be connected with science teaching and learning. A tenable assumption can be made that in non-western countries such as Zimbabwe, science teachers in addition to having thorough knowledge grounded in the teaching subject and its methods, must have a thorough grounding on the cultural context and indigenous world-view in which they teach so that they are better able to exemplify and link their subject domain to realities and everyday experiences of their students. They have to demonstrate to their students the strengths and weakness of traditional culture relative to science as a way of knowing and viewing universe. Science teachers should be aware of their own inclination and commitment to their indigenous culture and how this may consciously or unconsciously be interacting with their instructional styles and preferences. These assumptions provide a basis for a promising line of research as justified by the following overview of socio-cultural variables.

**Significance of indigenous cultural variables to science education**

Issues defining a traditional world-view must have some bearing on what indigenous teachers believe and perceive about the nature of science and about their roles in teaching and learning. In this study it was expected that indigenous science teachers would have some inclination to indigenous cultural values and beliefs and that this orientation would have an inverse relationship to their perception of the nature of science, societal issues, and instructional ideology which are themselves expected to be correlated positively. The literature suggests that this hypothesis is tenable (Ogawa, 1986; Ogunniyi, 1983, 1986, & 1988; Yakubu, 1994; Cobern, 1991 & 1993; MacGaffey, 1986). Cobern (1993) notes 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 (p. 1) and thus the issue of cultural context should be taken seriously. Morris (1983) noted that education does not take place in a cultural vacuum, "it occurs against the background of a view of the world and of humanity's place in it which are characteristics of a particular society" (p. 97). Although in the Third World in general and in Africa in particular, modern science is an imported phenomenon, commitment to an indigenous world-view may be a very important reason why the scientific world-view is not readily adopted and applied to problem situations (Yakubu, 1994). Morris (1983) observed that African students' commitment to science is sustained only through the duration of courses of study to the extent that "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). Could this inclination on the part of students be related in any way to the inclination of indigenous African science teachers? How is commitment to an indigenous culture related to science teachers' perception of how science instruction should be conducted in their classrooms? These are significant questions if the experience of some westerners who have taught in Africa is anything to go by. For example, Shrigley (1983) recollected his experience in a teachers' college in Nigeria as follows:

I found students who were seeking simple answers to complex scientific phenomena, distressed by the tentative nature of the scientific enterprise. There was a tendency to embrace, even tongue-in-cheek, information having a superstitious base, but at least a definite answer, in preference to wrestling with several scientific alternatives. To illustrate the frustration that the lack of sure and fixed knowledge can generate, one student made a public appeal that I teach only what scientists were sure of! (p. 427)

This general situation whereby students view scientific knowledge with a frame of reference of their own culture and whereby their world-view clashes with the scientific world-view probably applies to traditional cultures elsewhere other than Africa. The above quote also demonstrates that the authoritarian view of scientific knowledge may have originated from the preservice student teachers' culture-of-origin. The quote also begs the question, should educators assume that in the 3 or 4 years preservice teachers spend in a teachers college, they can clear the apparent contradictions in the world-view originating from the teachers' culture and the one acquired in science? Research suggests that the answer to this question must be "no". For example, in Nigeria,
Jegede and Okebukola (1991a & 1991b) found that socio-cultural factors can serve as filters to learning science. In a recent study of pre-degree science students in Nigeria, Jegede and Okebukola (1991b) observed that the traditional world-view influenced the way students perceived and interpreted observations. They found that 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 high level of religious belief and therefore they concluded that "it does seem that African traditional beliefs exerted the most influence on observational tasks in comparison with gender and religious affiliations" (p. 43). This suggests that even adults with a reasonable amount of exposure to science are still significantly influenced in their thinking and actions in science by their traditional beliefs, a finding reported in the Oggunniyi studies in Nigeria (Ogunniyi, 1988).

It is therefore essential that science educators and researchers understand the world-views, both from the culture of origin and from science education, held by science teachers. The traditional world-view in non-western culture represents a perception of reality that is different from the scientific world-view to be developed in science education. Students as well as teachers growing up in a traditional society must somehow deal with the contradiction which inevitably arises from the two world-views. Unfortunately, it is not always clear from the literature whether science teachers growing up in a traditional culture have a commitment or not to indigenous world-view and how their value system relates to their conception of the nature of science or to instructional ideology. Previous studies indicate that traditional African values and beliefs influence the acquisition and adoption of science and its values. However, a majority of the studies on which the influence of socio-cultural effects are inferred are based on samples of science students, often at pre-university level. Few of these studies explore the nature of influence of socio-cultural variables where science teachers indigenous to a traditional culture are involved, although this can be inferred from the theoretical basis and from the results of several studies in western countries linking science teachers' dogmatism and instructional ideology. In general, dogmatic teachers were
closed minded, authoritarian, and exhibited a traditional non-inquiry instructional ideology (Harty & Jones, 1978; Symington & Fensham, 1976; Lazarowitz, 1973). In these studies, teachers who had a preference for inquiry were more humanistic, less dogmatic, and less closed-minded. Closed-minded teachers preferred obedient, quiet, reserved pupils who liked to work alone and who readily accepted judgment of authorities; closed-minded teachers were generally more resistant to curriculum change and hence teachers' orientation towards inquiry and attitudes towards science as implied in curriculum materials was found to be negatively correlated to dogmatic scores. Teachers scoring high on dogmatic scales were more traditional in their beliefs about their classroom behavior and they exhibited less inquiry behaviors and came from extremely religious environments (Wavering, 1990). Extrapolating these findings to traditional culture, an orientation or preference towards indigenous culture (which is often closed and authoritarian) on the part of science teachers is expected to be reflected in their preferred instructional ideology and in their views and beliefs concerning the nature of science and scientific knowledge. This study was designed to measure the extent to which secondary science teachers are oriented towards traditional culture and how their orientation to indigenous culture is related to instructional ideology preferences. In particular, this study was designed to provide answers to questions such as these. In what kind of socio-cultural environment did science teachers grow? Do indigenous science teachers have an orientation to traditional culture? To what extent were they oriented towards traditional culture? How is their orientation to indigenous culture related to their instructional ideology and to conceptions of the nature of science?

**Hypotheses**

A researcher developed orientation to indigenous culture scale (OICS) and a science teacher instructional preference scale (STIPS) (Jones & Harty, 1978) were administered to all 66 secondary science teachers enrolled in an inservice Bachelor of Education (BEd) degree program at the University of Zimbabwe; 63 (95.45%) returned completed questionnaires. Although technically
these teachers are students in the BEd program, they are referred to as "BEd science teachers" in this article.

It was expected that the teachers' level of commitment to indigenous cultural values and beliefs would bear a direct and positive relationship to traditional instructional ideology. In particular, a high level of commitment to traditional culture should be associated with a high level of commitment to traditional non-inquiry instructional ideology and to an authoritarian view of the nature of science and scientific knowledge. The following hypotheses were tested:

H1: BEd science teachers will have a high orientation toward African traditional culture.

H2: BEd science teachers will have a greater preference for traditional science instructional ideology than for inquiry instructional ideology.

H3: There will be a significant negative relationship between BEd science teachers' orientation to indigenous culture and inquiry instructional ideology.

H4: There will no correlation among BEd science teachers' orientation to indigenous culture and preference for traditional instructional ideology preference, gender, age, teaching experience, academic and professional qualifications, and family and socio-cultural backgrounds.

Sample

The final sample for this study consisted of 63 certified secondary science teachers who had begun the final year of a two year Bachelor of Education (Science) degree program at the University of Zimbabwe. The teachers on the program came from all nine educational administrative regions in Zimbabwe. All of them were indigenous Zimbabweans and were certified and experienced in teaching school science in form one through four (grades 8-11). Teachers on the BEd program are being prepared to teach science to all levels of the secondary sector including Form 6 (grade 13) and are also expected to be able to be effective in curriculum development, to teach in teachers colleges, and to service other divisions of the Ministries of Education (University of Zimbabwe, 1994).

In 1994, the BEd science program was comprised of nearly all male teachers (87.30%); only 9 females were in the program. Over 95% of all the science teachers were 35 years of age or younger; a majority (41) were in the 26–30 age bracket and only three teachers were 31 years old or older. All
of the teachers were trained and certified after Zimbabwe got its independence in 1980; more than 95% had nine or fewer years teaching experience. The majority (63.49%) had at least one pass in one of the sciences or mathematics at Advanced level. Given the fact that there is no kindergarten, advanced level is comparable to grade 13 on the 7–4–2 system of education, i.e., 7 years primary, 4 years basic secondary (junior and ordinary level), and 2 years advanced level. Twenty three had O level (grade 11) qualifications. All of the science teachers except 3 had a certificate in education (CE). The certificate in education is a non-graduate professional qualification, in order to earn a BEd degree a CE holder needs another two years at the university.

Their academic performance in college and university was average. Their performance in the final examinations given at the end of Part I of the BEd program in 1993 showed that of the five subjects assessed, their performance was weakest in the science curriculum theory course where a disproportionately large number (43) or 65.15% obtained a third class pass, i.e., their criterion referenced scores lay somewhere between 50% and 59%. Forty five (45) teachers representing 71.43% of the sample grew up in a religious environment in which both Christianity and traditional religions were practiced. Only two respondents claimed that they grew up in a non-religious environment. When asked to indicate their current religious practices, 42.86% indicated both Christianity and traditional, 41.27% indicated Christianity, and 14.28% were non-religious. In this sample, hardly anyone was purely traditionalist in religious belief. Nearly 70% grew up in the rural areas or the countryside and the rest grew up at a mining center (23.81%), or in a city (3.17%), or commercial farm (3.17%). The responses of science teachers concerning the level of literacy, education, and occupation of their parents showed that a very small number of parents representing less than 8% were unable to read and write. In general, the majority of parents had some literacy. Over 68% of mothers and more than 53% of fathers, had received at least primary level education.
Instrumentation

For the data reported in this article, the primary instruments were two scales measuring science teachers' orientation to indigenous culture (ECAS) and science teacher instructional ideology preference scale (STIPS) (Jones & Harty, 1978). The STIPS is comprised of two 10-item subscales, the inquiry and traditional subscales. In responding to this scale teachers indicate their attitude toward how they believe science should be taught in their own classrooms. The 20 statements of the STIPS are matched with a five point Likert type scale ranging from "1" strongly disagree to "5" strongly agree. In this study, the odd–even split half internal consistency coefficient of the subscales upon adjustment via the Spearman–Brown prophecy formula was .54 for the inquiry subscale and .59 for the traditional factor. These coefficients were substantially lower than internal consistency reliability of .73 for the inquiry and .79 for the traditional subscale reported by Jones and Harty (1978).

The orientation to indigenous scale (OICS) contained 42 statements which purported to measure science teachers' "personal belief and orientation towards traditional culture in Zimbabwe" by assessing their level of agreement to the assertions on a five-point scale "1" strongly disagree to "5" strongly agree. The OICS yields a total score and 8 subscores representing an orientation to eight categories of indigenous culture. The total OICS score gave an indication of the level of inclination of science teachers towards traditional values and beliefs; the 8 subscores served to indicate the indigenous culture profiles of the teachers on 8 dimensions related to and constituting the values and beliefs ascribed to indigenous culture in Zimbabwe. For the items written to express a likely perception in traditional culture, a "disagree" corresponds to a low orientation to indigenous culture (OICS) while "agree" corresponds to a "high" OICS. For items written to express an unlikely perception in traditional culture "agree" corresponds to a low orientation to indigenous culture while "disagree" carries the opposite meaning; these items had their scores reversed in entering data for analysis.
A general review of the OICS was done by one expert in science education and three experts in Shona religions, philosophy, and languages. Further validation work and revision of the OICS is pending based on the knowledge gained from this study. Some evidence of construct related evidence of validity was established by examining correlations between the OICS score and its 8 subscores (Table 1). All of the eight subscores were positively and significantly correlated to the total OICS score at the .05 level of significance. This relationship between the total score and the eight subscores was to be expected since it was theorized that the subscales measured and contributed to the respondents' overall inclination to indigenous traditional culture. The subscales themselves had relatively low correlations among themselves. Although they measured the same construct, they were relatively independent, and thus it can be tentatively assumed that they

| Table 1. Correlation matrix for OICS scale and OICS scale subscores (n = 51) |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| OIC             |     |     |     |     |     |     |     |     |     |
| REV             | .59**| 1   |     |     |     |     |     |     |     |
| SEX             | .50**| .22 | 1   |     |     |     |     |     |     |
| NAT             | .46**| .15 | .05 | 1   |     |     |     |     |     |
| CAS             | .60**| .12 | .17 | .18 | 1   |     |     |     |     |
| FAM             | .57**| .24 | .23 | .12 | .25 | 1   |     |     |     |
| REL             | .66**| .32*| .07 | .16 | .55**| .38**| 1   |     |     |
| PROB            | .44**| .19 | .30*| .01 | .15 | .04 | .09 | 1   |     |
| SOC             | .53**| .37**| .37*| .23 | .02 | .22 | .07 | .31*| 1   |

*Significant at the .05 level.

**Significant at the .01 level.

Note: The scale and subscales were: OIC = orientation to indigenous culture; REV = reverence for authority figure; SEX = sex role stereotype; NAT = view of nature; CAS = causal attribution; FAM = family structure preference; REL = religious ideology; PROB = problem solving procedure; and SOC = orientation to social change.
measured different aspects of the traditional culture. For example, the respondents' "reverence for authority figures" was only modestly correlated to the other factors, the relationship approaching significance only for their "religious ideology" \( r = .32 \) and for their "orientation to social change" \( r = .37 \). This would be expected since religiously, reverence for authority figures is emphasized in this culture. Orientation to social change is undoubtedly connected to the religious belief one holds and to how much one perceives change as emanating from elder members of the society. It must be noted also that Table 1 shows that the factor "religious ideology" was clearly associated with their views on "causal attribution" \( r = .55 \ p < .001 \) as would be expected in a deeply religious culture. In this case people with an ideology marked by belief in ancestral worship would be expected to attribute fortune, achievement and success to ancestral spirits, and failure and misfortune to witchcraft or other spiritual agents. Their "view of nature" was a factor not related significantly to the other seven. The orientation to indigenous culture scale (OICS) was, overall, fairly reliable with a split-half reliability of .71. This reflects an internal consistency coefficient of .83 after applying the Spearman–Brown prophecy formula to correct for the underestimation inherent in computing the split-half reliability (Borg & Gall, 1989).

**Results**

**Profiles of science teachers' orientation toward indigenous culture (OICS)**

The OICS score serves as an index of the extent to which science teachers are committed to or oriented toward traditional cultural values and beliefs. On the OICS, a maximum score of 210 indicates a very strong inclination towards indigenous culture, a score of 42 serves as an index for a very low orientation to indigenous culture, and a score of 126 indicates a "neutral" position, i.e., neither orientation nor lack of orientation toward indigenous culture. Table 2 shows a summary of the scores and whether they significantly deviated from "neutral". A score significantly less than the "neutral" score of 126 suggests a low orientation toward indigenous culture and that significantly larger a "high" inclination towards traditional culture and vice versa.
<table>
<thead>
<tr>
<th>Indigenous Culture Scale Interpretation</th>
<th>Mean Score (S)</th>
<th>SD</th>
<th>d-Score (S - N)</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation to indigenous culture scale (42): degree or extent of personal identification one feels towards indigenous culture; a high degree of agreement with the items constitutes a high degree of orientation towards indigenous culture</td>
<td>102.49 [2.44]</td>
<td>13.66</td>
<td>- 23.51</td>
<td>- 13.65***</td>
</tr>
<tr>
<td>Reverence for authority figure (6): level of reverence for authority, i.e., the extent a respondent perceived locus of control to lie with elders</td>
<td>17.11 [2.85]</td>
<td>3.13</td>
<td>- 0.89</td>
<td>- 2.25*</td>
</tr>
<tr>
<td>Sex role stereotype (5): extent to which the respondent perceives sex roles and endorses inequality between sexes</td>
<td>8.59 [1.72]</td>
<td>2.82</td>
<td>- 6.41</td>
<td>- 17.72***</td>
</tr>
<tr>
<td>Religious ideology (6): extent to which the respondent orients towards traditionalist religious beliefs whereby ancestors and other spirits are the kingpins of society</td>
<td>14.92 [2.49]</td>
<td>3.76</td>
<td>- 3.08</td>
<td>- 6.40***</td>
</tr>
<tr>
<td>Family structure preference (5): extent to which the respondent prefers extended family structure, goals, and values</td>
<td>14.13 [2.83]</td>
<td>3.07</td>
<td>- 0.87</td>
<td>- 2.23*</td>
</tr>
<tr>
<td>Causal attribution (5): extent to which the respondent attributes success and failure to ancestors or to spiritual agents and hence a perception of causality</td>
<td>10.90 [2.18]</td>
<td>3.58</td>
<td>- 4.10</td>
<td>- 9.07***</td>
</tr>
<tr>
<td>View of nature (5): extent to which a respondent perceives the natural environment as sacred and the need for harmonious existence with it</td>
<td>13.85 [2.77]</td>
<td>3.63</td>
<td>- 1.15</td>
<td>- 2.47*</td>
</tr>
<tr>
<td>Orientation to social change (6): level of preference for the tradition, i.e., a perception that tradition should be maintained</td>
<td>14.57 [2.43]</td>
<td>2.41</td>
<td>- 3.43</td>
<td>- 10.82***</td>
</tr>
</tbody>
</table>

* Significant at the .05 level.

*** Significant at the .001 level.

a Number in parentheses indicates number of items comprising the scale or subscale.

b The numbers in parentheses are the score equivalents on the 5-point scale.

c The d-Score is the deviation score obtained by subtracting neutral score (N) for that scale or subscale from its scale or subscale score (S). The neutral score is obtained by multiplying the number of items in that scale or subscale by a value of '3'.
The average total OICS score obtained by summing responses to the 42 items was 102.49 with a standard deviation of 13.66; this score deviated significantly from "neutral" (d = -23.51 t = -13.65 p ≤ .0001). This total mean OICS score is equivalent to a score of 2.44 on the 5-point scale. Overall, science teachers in this study had a low orientation toward indigenous culture and thus research hypothesis (H1) is not supported. 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. Table 2 shows the results of the subsequent analysis of responses to the eight OICS subscales. The score for each was significantly lower than the "neutral" score for that subscale hence the negative reported t-values. This sample of science teachers had a consistently low orientation to the eight dimensions of indigenous culture in Zimbabwe. This may not be surprising for a sample of science teachers who have had long years of formal education and contact with western culture.

The science teachers' response profiles after aggregating "strongly disagree" and "disagree" responses modes to give "disagree" and after similarly combining "agree" and "strongly agree" to give "agree" were as follows. Items fitting the sex role stereotype, and problem solving showed the lowest mean scores and thus respondents had the lowest orientation to an indigenous perspective on these aspects. Rather their responses to these factors showed an orientation which would be desired in modern science education. For example after aggregating agree and strongly agree, 92.06% were in agreement to the statements "looking to the future, science education will be equally useful to boys and girls" and "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" and about 81% disagreed that "direct presentation of ideas for solving problems by the teacher is to be preferred since in society children generally learn by being told" suggesting a lack of preference for authoritarian top-down problem solving procedures. A substantial number however
expressed a view consonant with traditional values. For example, 38.71% thought that in solving problems it is necessary that students get "the expected or right answers to successfully complete the activity" and that 36.51% perceived that "while a spirit of questioning is good, there are many aspects of our lives and beliefs which should be accepted as they are".

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 (Table 2). 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. More than 90% believed that "that there are teachings from other cultures which are valid if adopted or adapted to our own way of life". Just over 52% agreed that "modern technology such as radio and television has contributed more to the moral decay of traditional culture than to its progress". They were almost equally split on their response to the statement "a scientific perception of reality can develop in a society with largely traditional perspectives" (49.15% disagreeing and 40.68% agreeing).

On their orientation to "reverence for authority figures" they showed slight inclination towards indigenous culture on 4 of the items. For example, on the item "the teacher has a role to ensure that pupils' behavior conforms to that expected of them by elders without questioning", they were almost split between those agreeing (50.71%) and those disagreeing (44.45%). They also had a slight inclination towards an extended family goal structure. Just over 49% agreed that "one problem with nuclear families is that traditional religious practices become negated". Fifty eight percent and 56% respectively believed that "efforts should be made to keep extended families so that the moral fabric can be preserved" and "even if one works and lives in an urban center/town, it is imperative to maintain a rural home". While they did value some traditional oriented aspects
of family, they were also positive in their responses regarding the need to control family or population size. For example, 62.25% did not believe that "family planning programs restrict individual families' right to have as many children as possible", while 84.16% believed that "population growth is a growing problem in Zimbabwe, it is irresponsible to have as many children as possible".

Table 2 shows that there was a moderately strong positive and significant relationship (r = .55) between their assessment on causal attribution and religious ideology. While 59.01% did not have a concern that "my religious beliefs are not congruent with the scientific world-view I have to teach" 32.79% did. Only 49.21% believed it unlikely that "natural calamities such as drought and floods are infliction or punishment on society by angry tribal spirits who should be appeased" and another 49.20% did not believe that "things that happen in our lives may be caused by another person or by an ancestor". On the other hand 76.19% agreed that "it is all right for people to raise questions about even the most sacred religious matters of Zimbabwe's traditional culture". This suggests that the respondents were not all not inclined to indigenous religious ideology or beliefs although they appeared to be relatively open-minded. For example, 63.49% disagreed that when someone challenged their traditional beliefs, it is their immediate responsibility to convince them to change their perspectives so that they match their own, 26.99% agreed. The majority of respondents did not appear to accept an ancestral spirit 'cause' of events or fortune, and a majority do not seem to hold superstition regarding the cause of accidents or misfortune. For example 71.43% did not agree that an individual's effort without ancestral blessing may not be enough to succeed in one's endeavors and that when there is a serious sickness or death in the family, some bad person or evil spirit caused it. About 75% agreed that if an accident, e.g., car crash results in serious injury or a death of a person, it is unnecessary to seek divine guidance to ascertain just how that particular person was the target.

Their views on the relation between humans and nature were divided; 59% believed that "there is a need to live in harmony with nature and other living things rather than seek to explore
and subjugate them. A sizable number (38.09%) agreed that "large scale collection and sale of wild fruit for profit is one way humans have diminished the sacredness and religious significance of nature". The respondents were further divided into those agreeing (46.03%) and those disagreeing (49.20%) to the assertion that "nature must be exploited only to a level necessary to satisfy the subsistence needs of the people rather than be turned into a source of commercial profit". Respondents generally expected a harmonious relationship with nature.

**Profiles of science teachers' instructional ideology preference**

Table 3 and Table 4 show the results of analyzing BEd science teachers responses to the items on the instructional preference scale. In preparing the data in both tables, "agree" and "strongly agree" responses and "disagree" and "strongly disagree" responses were aggregated and reported as percent "agreeing" and percent "disagreeing" respectively. A total mean score plus the mean scores for individual items are reported. When "strongly" agreeing to either the inquiry or non-inquiry item(s) a maximum score of 5 for the individual items and 50 for the subscale could be achieved. When strongly disagreeing, a minimum score of 1 for each item and 10 for the subscale was attainable. The index of neutrality, i.e., uncertain or undecided, was 3 or the middle point of the scale for individual items or 30 for the subscales. Both Table 3 and Table 4 show what has arbitrarily been called a "d-score" as well as the results of testing for significance using the one group t-test. The d-score represents the deviation of a score from the neutral index, i.e., the difference between the score and the neutral value. A score which is significantly higher than the neutral index indicates a preference for either inquiry or traditional ideology.

**Assessment of inquiry preference**

Table 3 shows that BEd science teachers in this sample scored a total mean score of 38.35 (SD = 4.20) on the inquiry preference subscale. This score is significantly (d-score = 8.35) higher than the neutral position of 30 (t = 15.68 p < .0001). The BEd science teachers in this study had a significant preference for inquiry instructional ideology. Except for item 6 for which they were neutral (mean = 3.08), teachers in this sample scored each item significantly higher than its
Table 3. BEd science teachers' orientation to inquiry instructional ideology (N = 63)

<table>
<thead>
<tr>
<th>Inquiry Item&lt;sup&gt;a&lt;/sup&gt;</th>
<th>% Disagree (%)</th>
<th>% Agree (%)</th>
<th>Mean</th>
<th>S.D.</th>
<th>d-</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The student should figure out on his/her own the important concepts of the materials being studied rather than receiving them directly from the teacher.</td>
<td>33.33</td>
<td>63.50</td>
<td>3.35</td>
<td>1.30</td>
<td>+0.35</td>
<td>2.13</td>
<td>.0183</td>
</tr>
<tr>
<td>2. To learn science the student should be provided situations which exemplify concepts but which require him to figure them out himself from the examples encountered.</td>
<td>1.59</td>
<td>96.82</td>
<td>4.38</td>
<td>0.61</td>
<td>+1.38</td>
<td>18.05</td>
<td>.0001</td>
</tr>
<tr>
<td>3. In the lab the student should be free to identify on his/her own the relevant questions and means of investigation for pursuing possible results.</td>
<td>26.98</td>
<td>66.67</td>
<td>3.60</td>
<td>1.19</td>
<td>+0.60</td>
<td>4.04</td>
<td>.0001</td>
</tr>
<tr>
<td>4. Students should have a major role in making many of the decisions about what are the best means for learning the concepts in the materials being studied.</td>
<td>47.62</td>
<td>49.21</td>
<td>3.08</td>
<td>1.25</td>
<td>+0.08</td>
<td>0.50</td>
<td>.3078</td>
</tr>
<tr>
<td>5. The learning of a scientific concept should include the alternative views, weaknesses of current explanations, and doubts about validity of the conclusions.</td>
<td>1.59</td>
<td>92.06</td>
<td>4.19</td>
<td>0.62</td>
<td>+1.19</td>
<td>15.28</td>
<td>.0001</td>
</tr>
<tr>
<td>6. Instructional materials must encourage students to formulate alternate ideas to concepts encountered.</td>
<td>3.17</td>
<td>96.83</td>
<td>4.35</td>
<td>0.65</td>
<td>+1.35</td>
<td>16.44</td>
<td>.0001</td>
</tr>
<tr>
<td>7. Each student should use his/her own ways of exploring, interpreting, and reporting the experiences done by everyone during a lab investigation.</td>
<td>34.92</td>
<td>61.90</td>
<td>3.43</td>
<td>1.13</td>
<td>+0.43</td>
<td>3.01</td>
<td>.0019</td>
</tr>
<tr>
<td>8. Students should encounter new concepts to be learned in lab investigations before they are covered in class.</td>
<td>25.60</td>
<td>61.90</td>
<td>3.52</td>
<td>1.22</td>
<td>+0.52</td>
<td>3.42</td>
<td>.0005</td>
</tr>
<tr>
<td>9. Students must challenge the truth of currently held scientific concepts and principles by seeking alternative interpretations that they can formulate, justify, and substantiate.</td>
<td>0.00</td>
<td>98.41</td>
<td>4.44</td>
<td>0.53</td>
<td>+1.44</td>
<td>21.55</td>
<td>.0001</td>
</tr>
<tr>
<td>10. To learn a scientific law or principle students should be provided exemplifying instances from which they infer it without the teacher giving it.</td>
<td>6.45</td>
<td>91.94</td>
<td>4.11</td>
<td>0.73</td>
<td>+1.11</td>
<td>12.06</td>
<td>.0001</td>
</tr>
<tr>
<td>Total Inquiry Preference Score</td>
<td>38.35</td>
<td>4.20</td>
<td>+8.35</td>
<td>15.68</td>
<td>.0001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Item numbers same as they occurred on the scale.

<sup>b</sup>The 'd-score' represents the deviation of a score from the neutral index i.e. difference between the score and the neutral value. Neutral score is 3.00 for individual items and 30 for entire subscale.

<sup>c</sup>The number in parentheses is the score equivalent on the 5-point scale.
neutral index. With respect to item 6, respondents were split between those agreeing that students should have a major role in making instructional decisions (49.21%) and those disagreeing (47.62%). Generally, their response profiles were such that over 60% agreed respectively with items 1, 4, 13, and 15 and better than 91% agreed with inquiry items 3, 6, 9, 10, 16, and 18. Respondents in the study accepted that students should have greater responsibility in accomplishing learning outcomes by inference, by discovering or by having them figure out important concepts or relationships. They also believe that during instruction, alternative view points or explanations should be encouraged and that the validity of conclusions should be challenged. BEd science teachers showed a high preference for inquiry instructional ideology.

Assessment of traditional or non-inquiry preference

Table 4 summarizes the responses of science teachers to the traditional or non-inquiry subscale. Overall, science teachers in this study showed a preference for traditional non-inquiry instructional strategies (mean = 33.63 t = 6.19 p < .0001). Of the ten items comprising this subscale, only 3 items (2, 7, & 14) were scored lower (disagree) than the neutral index of 3.00 thus demonstrating a non-preference for traditional non-inquiry ideology. For example, 88.89% disagreed with statement 2 "science should be taught as a discipline of conclusive and authoritative information which has been verified beyond dispute" and a further 80.95% disagreed with assertion 7 "students best learn important concepts of science through direct presentation of them by the teacher". The rest were scored significantly higher than the neutral index (items 5, 8, 11, 12, 17, 19, & 20) showing that teachers had preference for traditional non-inquiry ideology.

Respondents of this study exhibited a substantially high preference for non-inquiry. They believed that students should be explicitly told important concepts (item 5; 74.20% agree), should be given specific directions for experiments (item 11; 69.35% agree; item 19; 76.19% agree; and item 20; 69.84% agree). Some responses could have reflected a misconception of the nature of science, e.g., 88.89% believed that "the true nature of science should be illustrated to the student through the
Table 4. BEd science teachers' orientation to traditional non-inquiry instructional ideology as measured on the Jones-Harty STIPS (N= 63)

<table>
<thead>
<tr>
<th>Non-Inquiry Item</th>
<th>% Disagree</th>
<th>% Agree</th>
<th>Mean</th>
<th>S.D. d-Score</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Science should be taught as a discipline of conclusive and authoritative information which has been verified beyond dispute.</td>
<td>88.89</td>
<td>9.52</td>
<td>1.82</td>
<td>0.93</td>
<td>-0.18</td>
<td>-10.08</td>
</tr>
<tr>
<td>5. During instruction the student should be explicitly told the important concepts contained within the content dealing with the topic being studied.</td>
<td>20.96</td>
<td>74.20</td>
<td>3.63</td>
<td>0.98</td>
<td>+0.63</td>
<td>5.06</td>
</tr>
<tr>
<td>7. Students best learn important concepts of science through direct presentation of them by the teacher.</td>
<td>80.95</td>
<td>17.46</td>
<td>2.17</td>
<td>0.94</td>
<td>-0.83</td>
<td>-6.95</td>
</tr>
<tr>
<td>8. To truly understand a science discipline students should acquire a fund of useful factual information dealing with the content under consideration.</td>
<td>20.96</td>
<td>70.98</td>
<td>3.60</td>
<td>0.98</td>
<td>+0.60</td>
<td>4.78</td>
</tr>
<tr>
<td>11. During lab exercises students should follow specific directions on what to observe, measure, and report in order to find the right answers to the problem.</td>
<td>27.42</td>
<td>69.35</td>
<td>3.58</td>
<td>1.15</td>
<td>+0.58</td>
<td>3.97</td>
</tr>
<tr>
<td>12. The true nature of science should be illustrated to the student through the study of its technological applications and achievements.</td>
<td>1.59</td>
<td>88.89</td>
<td>4.21</td>
<td>0.68</td>
<td>+1.21</td>
<td>14.17</td>
</tr>
<tr>
<td>14. Lab experiments should be designed so that the correct results or answers will emerge for only those who follow the directions and procedures.</td>
<td>60.32</td>
<td>38.09</td>
<td>2.79</td>
<td>1.18</td>
<td>-0.21</td>
<td>-1.39</td>
</tr>
<tr>
<td>17. Investigations should follow the 'scientific method' as the best means for all to use to make discoveries.</td>
<td>1.59</td>
<td>93.65</td>
<td>4.37</td>
<td>0.66</td>
<td>+1.37</td>
<td>16.54</td>
</tr>
<tr>
<td>19. Lab investigations should follow specified directions and procedures pre-designed to illustrate a concept.</td>
<td>12.70</td>
<td>76.19</td>
<td>3.73</td>
<td>0.87</td>
<td>+0.73</td>
<td>6.70</td>
</tr>
<tr>
<td>20. The primary objective of lab experiments should be the development of manipulative skills and ability to follow directions which lead to planned results.</td>
<td>28.57</td>
<td>69.84</td>
<td>3.59</td>
<td>1.21</td>
<td>+0.59</td>
<td>3.84</td>
</tr>
<tr>
<td>Total Non-Inquiry Preference Score</td>
<td>33.63</td>
<td>[3.36]</td>
<td>4.54</td>
<td>+3.63</td>
<td>6.19</td>
<td>.0001</td>
</tr>
</tbody>
</table>

*a Item numbers the same as they occurred on the scale.

bThe 'd-score' represents the deviation of a score from the neutral index i.e. difference between the score and the neutral value. Neutral score is 3.00 for individual items and 30 for entire subscale.

cThe number in parentheses is the score equivalent on the 5-point scale.
study of its technological applications and achievements" (item 12) and that "investigations should follow the 'scientific method' as the best means for all to use to make discoveries" (item 17).

It was established that the BEd science teachers tend to view science in terms of its applications in improving human welfare and production of useful technology. They strongly believed in a single scientific method with a determinate number of procedural steps. For example, over 93% of the science teachers were affirmative that "the scientific method follows the five regular steps of defining the problem, gathering data, forming hypothesis, testing it, and drawing conclusions from it" (Shumba, 1994).

**Correlation matrix of instructional ideology, OICS, and demographic variables**

Table 5 shows the correlation matrix for socio-cultural and demographic variables and dependent variables measured in the study. BEd science teachers exhibited a significantly higher preference for inquiry ideology (mean = 38.35 S.D. = 4.20) than for traditional or non-inquiry instructional strategies (mean = 33.63 S.D. = 4.54) (t = 5.14 p = .0001). For this sample of teachers a high inquiry preference score was complemented by a relatively lower traditional inquiry preference score. The results of correlational analysis indicated a negative value of the Pearson product moment correlation (r = - .22 p = .05) which confirmed the inverse relationship between scores on the inquiry subscale and those on the traditional subscale. This result differs from that obtained by Jones and Harty (1978). They found a positive correlation of magnitude .32 and concluded that teachers "tended to respond with similar degrees of harmony to the items of both subscales" (p. 6).

Correlation coefficients were also computed to explore relationships among personal, academic, professional, and socio-cultural variables, and teachers' orientation to indigenous culture (OICS) and to instructional ideology (Table 5). Scores on the OICS were positively correlated to scores on the traditional subscale of the STIPS (r = .40 p < .05) but were barely negatively correlated to the inquiry subscale of the STIPS (r = -.03). Scores on the traditional subscale were positively
Table 5. Correlation among BEd science teachers' scores on the nature of science, instructional ideology, environmental-conservation, and cultural orientation

<table>
<thead>
<tr>
<th>VARIABLESb</th>
<th>NSKS</th>
<th>ECAS</th>
<th>SPT</th>
<th>SPI</th>
<th>NOSS</th>
<th>OICS</th>
<th>TTC</th>
<th>BED</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSKS</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECAS</td>
<td>.20</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPT</td>
<td>.18</td>
<td>.01</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td>-.12</td>
<td>.30*</td>
<td>-.22</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOSS</td>
<td>-.00</td>
<td>.27*</td>
<td>-.44**</td>
<td>.05</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OICS</td>
<td>-.05</td>
<td>-.22</td>
<td>.40*</td>
<td>-.03</td>
<td>-.07</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC</td>
<td>-.06</td>
<td>.04</td>
<td>.06</td>
<td>.02</td>
<td>.08</td>
<td>.15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BED</td>
<td>-.03</td>
<td>-.18</td>
<td>.23*</td>
<td>-.07</td>
<td>-.23*</td>
<td>.08</td>
<td>.27*</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significant at p ≤ .05.
**Significant at p ≤ .01.

Sample size n = 58 because 5 missing cases deleted.

Abbreviations for constructs in the study were as follows:

NSKS = nature of scientific knowledge score; ECAS = environmental conservation awareness score; SPT = preference for inquiry instructional ideology score; SPI = preference for traditional instructional ideology score; NOSS = nature of science score; OICS = orientation to indigenous culture score; TTC = pre-service teacher training score; and BED = BEd Part I score.

and significantly correlated to the BEd Part I scores (r = .23) raising a possibility that their ratings might partly reflect some orientation to the way science was being taught in the program. Other academic or professional variables such as subject specialization or qualification did not have a relationship to either instructional ideology or to OICS.

Age and teaching experience were significantly positively related to both traditional instruction ideology and to OICS but negatively correlated to inquiry instructional ideology. Older teachers tended to have a higher level of commitment to indigenous culture and relatively less preference for inquiry. Childhood (REN) and current religious practice (REP) are modestly
correlated to OICS but significantly correlated to traditional instructional ideology negatively. Literacy (MOL or FAL) or educational attainment levels (FAE or MOE) of their parents were significantly negatively correlated to preference scores for traditional instruction but were not related to preference for inquiry. Table 5 also shows that modest negative correlations exist between OICS and inquiry instructional ideology, nature of science, nature of scientific knowledge, and environmental-conservation awareness scores. Scores on the traditional subscale of the STIPS were significantly negatively correlated to the nature of science scores ($r = -.44$) and scores on the inquiry subscale were correlated positively to the environmental conservation awareness scores significantly ($r = .30$).

Discussion

This study explored relationships among indigenous Zimbabwean science teachers' backgrounds, beliefs regarding indigenous culture, and preferences concerning science instructional ideology. Relevance of doing so can be deduced from the following comment made with reference to Africans in general:

Every African who has grown up in a traditional environment will, no doubt, know something about this mystical power which often is experienced or manifests itself, in form of magic, divination, witchcraft and mysterious phenomena that seem to defy immediate scientific explanations. (Mbiti, 1990; p. 189)

This assertion demonstrates the existence of a different world-view in which it is believed, unlike in science, that every experience can and must be explained satisfactorily. Explanations go beyond the immediate physical or natural contingencies in traditional culture as apparent in Aschwanden (1982) conclusions about a subgroup of the Shona. He remarked that "the Karanga cannot conceive of the idea of disease or illness without, at the same time, taking into account such aspects as belief in God, ancestral spirits, man's relationship with nature, problems of marriage and of sexual intercourse, and many others" (p. xiv). Nelson (1982) notes the preoccupation of indigenous Zimbabweans "with this world and with the effects of the spirits on the welfare of the living" (p. 118) and that in the world-view of Zimbabweans "there is little room for chance or of the notion
that microorganisms or weather systems indifferent to human beings inadvertently affect their welfare" (p. 119). A Zimbabwean may, for example, make use of modern medicine because it relieves the symptoms but may still be concerned to know why an illness was inflicted upon him. It is expected therefore that indigenous teachers' conceptions of the nature of science and of instructional ideology are influenced by the attitude-value complex or world-view they acquired in indigenous culture or by the degree to which their beliefs were oriented towards indigenous culture. As noted in this article and by other researchers in comparable cultural contexts, the problem might lie in "indigenous cultural behavioral and thought patterns" (Yakubu, 1994; p. 344) which were different than in science.

It was expected therefore that indigenous teachers' instructional ideology would have a relationship to the attitude-value complex acquired in indigenous culture or by the degree to which they were oriented towards indigenous culture. This study found that teachers' orientation to indigenous culture scores were positively related to the scores representing preference for traditional non-inquiry instructional ideology and very modestly negatively related to preference for inquiry ideology. Although the orientation of teachers toward indigenous cultural values and beliefs was substantively low overall, item analysis profiles demonstrated teachers had some authoritarian tendencies on some items. This tendency was even clearer from their rating of the traditional non-inquiry subscale of the STIPS and thus it is important to raise implications this perception might have in science education. For example, respondents were split between those agreeing that students should have a major role in making instructional decisions. The majority believed that students should be "explicitly" told important concepts (74.20%), should be given specific directions for experiments (> 69%).

In African societies in general, there is reverence for authority figures or adults implying that the locus of control and authoritative knowledge lies with adults (Jegede & Okebukola, 1992). Authority figures are perceived as credible and infallible sources of information and solutions to problems and hence it is virtually inappropriate for children to query knowledge or decisions of
adults. Jegede and Okebukola (1992) note the negative consequence of authoritarianism as that it limits the extent to which students have a mind of their own. A further 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 other similar contexts (McKinley, et al., 1992; Prophet, 1990).

Further implications of the authoritarian character of indigenous culture can be drawn from the fact that in traditional society problem solving has to follow a fixed code of conduct and adhering strictly to the "correct" procedures laid down by tradition (Gelfand 1965). In fact it is said that all activities have a "correct" way by which they must be completed, an attitude which may have the effect of stifling experimentation and innovation. Consequently, the process of problem solving and other behaviors among traditionalists is often in a linear hierarchy from the top (ancestors and elders) to the bottom (junior members of the family or community). This often has a consequence that students hold an expectation that problem solving is finding out information that is already known and must be proved. In Zimbabwe, a potential consequence of authoritarian tendencies was noted in a recent evaluation which found that primary students were inclined to prefer to watch their teacher demonstrate rather than for them to participate on a hands on basis (Lewin & Bajah, 1991).

Another point for discussion concerns the finding that this sample of teachers showed both an inquiry preference as well as some traditional inquiry preference. This could imply that the Jones–Harty (1978) STIPS simply 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 assumption here is that these instructional ideologies form a continuum. The trend expected in the ideal situation where a high inquiry ideology is complimented by a low traditional instructional preference was indicated by a substantial inverse relationship between scores on the inquiry subscale and those on the traditional subscale ($r = -.22 \ p = .05$). This result was unlike that obtained by Jones and Harty
(1978) who observed a positive correlation and concluded that their teachers tended to respond
with similar degrees of harmony to the items of both subscales (p. 6). In the present study a
preference for traditional instructional ideology was correlated to BEd scores in Part I and thus
their rating could possibly reflect on the methods employed to deliver content on this program.
This could have created a response set which made the STIPS appear to have lower reliability
than it is capable of.

Although the STIPS had a low internal consistency and thus a low reliability when used
with this sample of teachers, findings obtained are still notable. For example, STIPS scores
enabled the researcher to simultaneously check a respondent's inclination relative to two
independent ideologies; if a scale which only measured the inquiry preference had been applied,
the tendency for preferring traditional instructional could easily have been missed and vice versa.
The finding that teachers in the present sample held both ideologies but one higher than the other
is significant. First, it would have been expected that having grown up in a non-western and
authoritarian environment they should have shown a higher level of traditional ideology than
found in the study. Lazarowitz and Lee (1976) noted the relative difficulty with which teachers
growing up in the less authoritarian environment of western culture have adopting an inquiry
philosophy. In fact lack of inquiry is often what seems to spawn contemporary criticisms about the
inability of school science education to bring about more widespread scientific literacy. What is
significant about the finding concerning teacher preference for traditional instruction in this study
is that it correlates significantly with teachers' inclination to a traditional culture which has
authoritarian tendencies. Some of the consequences were discussed in a preceding section.
Lazarowitz and Lee (1976) make an observation that:

an inquiry approach requires secondary science teachers to create teaching situations in
which students are stimulated to formulate problems and hypotheses. Students must design
their studies, and collect and interpret data. Different answers and experimental results
are accepted for discussion. Students are encouraged to participate in classroom discussion
and laboratory investigations. They are not told the question's answers or told that only one
right answer exists. (p. 455)
If we take traditional culture to its extremes, this approach is not directly supported. In traditional culture, problems cannot and should not be formulated unless of course one risks being labeled a witch. When solutions to problems are sought they are not considered tentative and the best scenario is that they should not be tentative, they must be absolute and final. Different answers or solutions cannot be tolerated, right answers exist. Unfortunately some teachers could be perpetuating this situation. These assertions are not unfounded as data reported in a recent masters' thesis show (Tsvere, 1992). Tsvere surveyed physics teachers and students at the Advanced level and found that 72.1% of over 800 physics students reported that they were not given the opportunities to design their own experiments. Only 28.8% of practicals stipulated in the syllabus were being done. She observes that:

teachers suggested that these aims [motivating students by stimulating and maintaining skills and standard techniques and preparing students for examinations] could best be accomplished through standard exercises and teacher demonstrations. May be that suggested why few projects were being done in schools (39.9%) and why 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; no page number)

BEd science teachers in this sample perceived that laboratory work should follow or tests the ability to follow specific directions and procedures leading to the "the right answers to the problem".

These observed authoritarian tendencies may possibly extend to the view held concerning the nature of science and scientific knowledge. For example, Table 5 showed that modest negative correlations exist between OICS and inquiry instructional ideology, nature of science scores measured on Kimball's (1967) model, Rubba-Andersen (1978) nature of scientific knowledge scores, and environmental-conservation awareness scores. These results are presented and discussed elsewhere (Shumba, 1994). Overall, they had reasonable levels of understanding of nature of science but demonstrated in some cases an authoritarian and naive view of scientific knowledge. For example, the BEd sample in this study did not see scientific knowledge as parsimonious and they
perceived of a single scientific method which had a determinate number of procedural steps; they
did not possess a definitive understanding of the use of models and/or the role or arbitrariness of
classification schemes in science. They accepted the view of science as an organized body of
knowledge. A significant majority had an inadequate understanding of the tentativeness of
scientific knowledge; they seemingly viewed "laws" as permanent and unchangeable
generalizations.

Conclusion

This study investigated the relationship between teachers' orientation to indigenous
culture and their instructional ideology. This knowledge is essential because what we already
know about African science teachers especially their culture of origin beliefs and factors is limited
and often conjectural. For example, Shrigley (1971), writing about his two year experience in a
Nigerian college said:

Students were inclined to view science as final and fixed. Some of the most uneasy moments
developed when dealing with problems having only tentative answers. In desperation, one
keenly-interested science student stood beside his desk and in typical African politeness
asked, "Why don't you teach only what scientists are sure of?". It is my conviction that
many traditional explanations to natural phenomena are, in part at least, the result of this
uneasiness sensed by the African when a phenomenon goes unexplained. Even a tongue-in-
cheek explanation seems better than no explanation at all. (pp. 211-212)

In addition to a growing body of research, this personal experience and interpretation of the way
African students learned science obviated the potential significance of the influence of culture-of-
origin factors, knowledge, and beliefs. This study articulated how influence of these beliefs might
act via the instructional ideology preference of science teachers.

It remains necessary to examine more closely how cultural factors manifest themselves in
classrooms. The research cited taken together with findings of this study point to the significance
of understanding traditional culture and utilizing that knowledge in curriculum innovation. On the
matter of curriculum, Mundangepfupfu (1988) suggests that:
A more systematic approach to curriculum decision making based on the curricular concerns of science educators in Africa is needed. One of these concerns is the existence of magico-traditional beliefs. It seems that without a non-partisan systematic distinction of magico-traditional beliefs from scientific beliefs science educators will remain largely ineffective in their attempts to inculcate the scientific world-view through science teaching although students may be indoctrinated. (p. 11)

She therefore surmised that the science methods courses should go beyond methods of teaching to an understanding the nature of both scientific and indigenous knowledge. This study collected information on dimensions such as teachers' personal orientation to indigenous culture and instructional ideology that may help in efforts to make the curriculum more relevant to Zimbabwe. With reference to the BEd program, there may be real opportunities in the methods and science curriculum theory courses to deal with indigenous culture as it relates to the science curriculum.

Overall, this study articulates the importance and relevance of culture-of-origin backgrounds, knowledge, and beliefs on science education. Further research should include more systematic validation of instruments to measure orientation to indigenous culture and must include observation data to ascertain how teachers handle beliefs and preconceptions they and/or their students acquire from traditional culture. Validation work is an important concern for pending research by the author. Furthermore, careful studies are needed to find out how dimensions of culture raised in this study are related among themselves and how they independently and together interact with science education. Perhaps then we will be better informed about variables that should be taken into account in order to achieve more universal adoption of the scientific world-view in a predominantly traditional-oriented society such as the case in Zimbabwe.

References


CHAPTER VI. INDIGENOUS ZIMBABWEAN SCIENCE TEACHERS' UNDERSTANDING OF THE NATURE OF SCIENCE RELATIVE TO MODELS OF THE NATURE OF SCIENCE AND RELATIVE TO PROFILES OF TEACHERS IN TWO COUNTRIES

A paper to be submitted to the Zimbabwe Journal of Educational Research

Overson Shumba

Abstract

This article describes perceptions of 63 secondary science teachers on the nature of science and how their perceptions were related to their commitment to indigenous cultural values, instructional ideology, and to awareness of science–related societal issues. Their perceptions were compared to two models of the nature of science and to perceptions of science teachers in two countries. On the Kimball (1967) model, their perception was found to be inadequate but on the Rubba–Andersen (1978) model, their perception of the nature of scientific knowledge was adequate. Scores on the two models were not correlated. Teachers in this study tended to view science in terms of production of useful technology and in improving human welfare and accepted the view of science as an organized body of knowledge. They perceived that there was a single scientific method which had a determinate number of steps. Academic, professional, and socio-cultural background variables were not related to the teachers' perceptions of the nature of science. Orientation to indigenous culture was positively correlated to a preference for traditional instructional ideology and both variables were negatively correlated to nature of science scores modestly.

Introduction

In Zimbabwe, as elsewhere in the world, science and technological literacy is an important goal of science education. Although the construct science and technology literacy is complex and multifaceted, numerous researchers identify understanding the nature of science as one of its most
important dimensions (Meichtry, 1993; Andersen, Samuel, & Harty, 1986; Lederman, 1992 & 1986; Lederman & Zeidler, 1987; Rubba & Andersen, 1978; Kimball, 1967). In Project 2061: Science for all Americans (American Association for the Advancement of Science (AAAS), 1989), scientific and technological literacy is defined in terms of understanding the nature of science and how scientists go about their work, understanding the overarching ideas and concepts of science as well as their applications, and appreciating the social, environmental, and economic implications of science and technology. The construct is relevant to science teacher education because there seems to be a connection between teachers' knowledge and understanding of the nature of the scientific discipline and their instructional preferences and students' learning (Lederman, 1992). Teachers with inadequate understanding of the nature of science cannot present an accurate notion of the nature of science or scientific knowledge. Tamir (1983) and Hodson (1988) postulated that understanding the nature of science is related to teachers ability to distinguish between teaching science as inquiry or by inquiry. Chiapetta, Sethna and Fillman (1991) reported that teachers with weak or lack of understanding of the nature of science fail to develop science ideas and concepts which they teach around "the models that scientists used to form these concepts" (p. 940). This resulted in superficial and parsimonious treatment of both subject matter and the nature of science. Chiapetta, et al. found also that teachers lacking understanding of the nature of science typically had greater dependence on texts, traditional instructional methods, greater concern with maintaining discipline and control, and other non-science task related concerns. Such teachers therefore failed to present science as a humane enterprise.

Chiapetta and others' (1991) research underscores why teachers should possess an adequate conception of the nature of science. Further, although non-western developing countries 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, several variables could confound the ability of science teachers to acquire an accurate notion of the nature of science in the developing non-western countries. First, acquiring an accurate conception of
the nature of science is expected to be confounded by the world-view they acquired in their culture of origin which is typically traditional. As the *American Heritage Dictionary* defines it, world-view is 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 (p. 2058). World-views are therefore fairly consistent impressions about the universe. Cobern (1993), Ogawa (1986), Ogunniyi (1988), and many others note that the traditional world-view is often at variance with the scientific world-view to be developed in science education. For example, Shrigley (1983) recalled and described his experience in a teachers' college in Nigeria as follows:

I found students who were seeking simple answers to complex scientific phenomena, distressed by the tentative nature of the scientific enterprise. There was a tendency to embrace, even tongue-in-cheek, information having a superstitious base, but at least a definite answer, in preference to wrestling with several scientific alternatives. To illustrate the frustration that the lack of sure and fixed knowledge can generate, one student made a public appeal that I teach only what scientists were sure of! (p. 427)

Frequently African students lack the spirit of science and do not possess a scientific way of looking at nature of which Odhiambo (1968) once said "the African must be saved (sic) from living two worlds— one of belief, and the other of natural science" (p. 45). Recently, evidence of the implications of socio-cultural context to views concerning the nature of science can be found in a recent study of pre-degree science students in Nigeria. Students who exhibited a high level of belief in African traditional cosmology were found to make significantly fewer correct scientific observations of biological structures and processes when compared with those with a high level of religious belief (Jegede & Okebukola, 1991).

A second problem confounding the image of the nature of science possessed might be national or societal expectations for science and technology in developing countries. In Zimbabwe for example, there is a societal expectation that science and technology should spur social and economic development (Government of Zimbabwe, 1991). Therefore, science can be perceived unrealistically in terms of aspects related to industrial production of goods and application of existing scientific knowledge to industrial processing (Odhiambo, 1968; Morris 1983; Chisman, 1984;
Nichter, 1984). This societal expectation appears to be implicated in the accuracy of teachers' image of the nature of science. For example, Cobern (1989) recently reported that Nigerian teachers viewed the purpose of scientific activity as producing useful technology and they perceived scientists as nationalistic and secretive about their work. Odhiambo (1968) conjectured that these expectations risked science to be easily treated as a technology or as a set of procedures and rules which then "limits the understanding of science to the facility with which one can regurgitate facts" (p. 39). In Zimbabwe this perception of linking science to national development is also reflected in the national school science syllabuses which emphasize practical applications of science in agriculture, in industry, and development of the community (Ministry of Education and Culture, 1992).

Statement of problem

Although scientific and technological literacy is complex and multifaceted, scientists and science educators agree that understanding the nature of science is some evidence of it. Traditionally, evaluation of scientific literacy is based on assessing students or teachers' conceptions of the nature of science against accepted models (Lederman, 1992; Meichtry, 1993). Two examples of accepted and well field-teste models are Kimball's (1967) nature of science and Rubba and Andersen's (1978) nature of science knowledge models. Due to the complexity and broadness of the construct nature of science, measuring and drawing inferences about understanding the nature of science may result in inaccurate conclusions (Meichtry, 1993; Doran, Guerin, & Cavalieri, 1974). Meichtry reviewed previous studies and noted the potential for inconsistencies in respondents conceptions when measured on different models. Doran, et al. (1974) suggested that the construct must be defined in the broadest terms. This study measured teachers' conceptions on the nature of science on two models in an attempt to deal with some of these concerns. As attested in the Lederman (1992) review, studies on the nature of science have been mainly conducted in the developed western countries and rarely in developing countries. In the latter, as demonstrated in a preceding section, conceptions of the nature of science may be distorted by the socio-cultural
environment, in particular the kind of world-view such an environment supports as well as by national expectations for science and technology. This study measured conceptions of the nature of science and explored how they were related to socio-cultural variables, to orientation to indigenous culture, to instructional ideology as defined by Jones and Harty (1978), and to a societal issue, environmental-conservation. The data obtained were compared to those of two countries, one a developed nation, USA, and the other a developing one, Nigeria. Comparative data benefits the education systems compared by offering insights into what aspects may need to be improved.

Research questions

This study surveyed all 66 in-service secondary science teachers enrolled in the Bachelor of Education (BEd) at the University of Zimbabwe in 1994; 63 (95.45%) returned completed questionnaires. The teachers on the program came from all nine educational administrative regions in Zimbabwe. All of them were indigenous Zimbabweans and were certified and experienced in teaching science school science in form one through four (grades 8-11). The BEd program prepares teachers for major teaching and curriculum development responsibilities in Zimbabwe's education system. Teachers on the BEd program are being prepared to teach science to all levels of the secondary sector including Form 6 (grade 13) and are also expected to be able to be effective in curriculum development, to teach in teachers colleges, and to service other divisions of the Ministries of Education (University of Zimbabwe, 1994). Although technically these teachers are students on the BEd program, they are referred to as "BEd science teachers" in this article. Specifically the study sought to provide answers to the following research questions.

1. What is the perception of BEd science teachers on the nature of science and on the nature of scientific knowledge?
2. How do BEd science teachers' perceptions compare to models of the nature of science and scientific knowledge?
3. How do BEd science teachers' perceptions compare to perceptions of teachers in other countries?
4. What relationships exist among science teachers' orientation to indigenous culture, instructional ideology, environmental conservation awareness, and understanding of the nature of science and scientific knowledge?
5. Are there differences in science teachers' conception of the nature of science and scientific knowledge when they are grouped according to categories of personal, academic, professional, and socio-cultural characteristics?

A rationale was developed in the background to the study to expect that the BEd science teachers would have an understanding of the nature of science and scientific knowledge at variance with accepted models. It is conjectured that BEd teachers' nature of science scores will be lower compared to scores of science teachers in western countries. This conjecture is realistic given the possibility that the teachers would have an orientation toward African indigenous culture. An orientation to indigenous culture as well as the socio-cultural variables were expected to be related to teachers' perception of scientific knowledge and processes inversely. High nature of science scores were predicted to be associated to higher awareness of societal issues, e.g., environmental conservation and to preference for inquiry instructional ideology.

Methodology

Although the primary data collection instrument was a questionnaire consisting of several scales, this article is focused mainly on presenting the nature of science and scientific knowledge profiles of BEd science teachers. BEd science teachers' conceptions of the nature of science was measured using a 29-item nature of science scale (NOSS) which is based on 8 assumptions or model points paraphrased in Figure 1 (Kimball, 1967; p. 111-112). Of the 29 items, 23 are negatively stated such that an "agree" response on these items implies disagreeing with the Kimball model of the nature of science. Only 6 items were positively stated. The NOSS scoring was adapted to a five point one (5 = strongly agree, agree, uncertain or neutral, disagree, strongly disagree = 1). Understanding of the nature of science could be demonstrated by agreeing to the model points or by disagreeing to the "negative" items and agreeing to the "positive" ones. In preparing the data for analysis, the 23 negatively stated item scores were reversed. According to this procedure, a total score of 29 represented total disagreement to the model response and thus inadequate understanding of the nature of science.
<table>
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<tr>
<th>Model Point</th>
<th>Description</th>
<th>NOSS Item Numbers</th>
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<tbody>
<tr>
<td>Point #1</td>
<td>The fundamental driving force in science is curiosity concerning the physical universe. It has no connections with outcomes, applications, or our uses aside from general of new knowledge.</td>
<td>4, 8, 12, 23, 24, 25, 29</td>
</tr>
<tr>
<td>Point #2</td>
<td>In the search for knowledge, science is process oriented, dynamic, ongoing activity rather than a static accumulation of information.</td>
<td>11</td>
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<tr>
<td>Point #3</td>
<td>In dealing with knowledge as it is developed and manipulated, science aims at ever-increasing comprehensiveness and simplification, emphasizing mathematical language as the most precise and simplest means of stating relationships.</td>
<td>7, 10</td>
</tr>
<tr>
<td>Point #4</td>
<td>There are many methods of science as there are practitioners.</td>
<td>1, 3, 9, 13, 15, 17, 21, 27, 28</td>
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<tr>
<td>Point #5</td>
<td>The methods of science are characterized by a few attributes, which are more in the realm of values than techniques e.g. dependence upon sense experience, use of operational definitions, arbitrariness of definition and schemes of classification or organization, and the evaluation of scientific work in terms of reproducibility and of usefulness in furthering scientific inquiry.</td>
<td>2, 16, 19</td>
</tr>
<tr>
<td>Point #6</td>
<td>A basic characteristic of science is faith in the susceptibility of the physical universe to human ordering and understanding.</td>
<td>6, 14</td>
</tr>
<tr>
<td>Point #7</td>
<td>Science has a unique attribute of openness of mind, allowing for willingness to change in the face of evidence, and the openness of the realm of investigation, unlimited by such factors as religion, politics or geography.</td>
<td>18</td>
</tr>
<tr>
<td>Point #8</td>
<td>Tentativeness and uncertainty mark all of science. Nothing is ever completely proven in science, and recognition of this fact is a guiding consideration of the discipline</td>
<td>5, 20, 22, 26</td>
</tr>
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Figure 1. The eight assumptions characterizing the nature of science on the Kimball-model.
A score of 87 represented a neutral perception, i.e., neither agreeing nor disagreeing with the Kimball model. A maximum score of 145 represented strong agreement to the model and adequate understanding of the nature of science.

Internal replication was achieved by simultaneously administering the Rubba and Andersen (1978) nature of scientific knowledge scale (NSKS). The Rubba and Andersen model describes scientific knowledge as amoral, creative, developmental, parsimonious, testable, and unified as summarized in Figure 2. The nature of scientific knowledge scale is a six factor and 48 item Likert type scale. Each subscale contains four positive and four negative items on which they receive from one to five points which are then summed to give the subscale score. Summing these subscale scores gives a composite NSKS score. A minimum of 8 points and a maximum of 40 points can be scored for each subscale. A "neutral" score on the subscale is 24 points. Similarly a minimum of 48 points and a maximum of 240 points for the entire NSKS is possible. A "neutral" score on the overall NSKS is 144 points.

Both the nature of science and the nature of scientific knowledge are built on similar understandings (Meichtry, 1993). However, the nature of science is broader and includes aspects on the nature of scientific knowledge, nature of the scientific enterprise, and nature of scientists (Doran, et al., 1974). The Rubba-Andersen (1978) model is more specific to the nature of scientific knowledge, it focuses on the nature of scientific ideas and claims, the products of scientific activity. International comparisons in this study were based on the data obtained from Andersen, et al. (1986) and Coben (1989) for the nature of science profiles, and from Lederman (1986) for the nature of scientific knowledge profiles.

Validity and reliability of scales

Validation work and field testing reported in the literature was largely accepted in this study. Some construct related evidence of validity was established in this study by examining the correlation matrix of NOSS and NSKS scores and sub-scores. Reliability was defined in the study
<table>
<thead>
<tr>
<th>Model Factor</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Amoral</td>
<td>Moral judgment can be passed only on the application of scientific knowledge, not on the knowledge itself.</td>
</tr>
<tr>
<td>Creative</td>
<td>Scientific knowledge is a product of the human intellect. Its invention requires as much creative imagination as does the work of an artist, a poet, or a composer; it embodies the creative essence of the scientific inquiry process.</td>
</tr>
<tr>
<td>Developmental</td>
<td>Scientific knowledge is never &quot;proven&quot; in an absolute and final sense; it changes over time. Beliefs that appear at one time may be appraised differently when additional evidence is at hand. Previously accepted beliefs should be judged in their historical context.</td>
</tr>
<tr>
<td>Parsimonious</td>
<td>Scientific knowledge tends toward simplicity but not to the disdain of complexity. It is comprehensive as opposed to specific. There is a continuous effort in science to develop a minimum number of concepts to explain the greatest possible number of observations.</td>
</tr>
<tr>
<td>Testable</td>
<td>Scientific knowledge is capable of public empirical test; its validity is established through repeated testing. Consistency among test results is a necessary but not a sufficient condition for the validity of scientific knowledge.</td>
</tr>
<tr>
<td>Unified</td>
<td>Scientific knowledge is born out of an effort to understand the unity of nature. The knowledge produced by the various specialized sciences contribute to laws, theories, and concepts. This systematized body gives science its explanatory and predictive power.</td>
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</table>

Figure 2. The six factors of the Rubba–Andersen model of the nature of scientific knowledge and their interpretation.

as the level of internal consistency of the individual subscales comprising the questionnaire used to gather data for the study. According to Borg and Gall (1989) the reliability coefficient reflects the extent to which a measure is free of error variance. The odd–even split–half internal consistency procedure whereby the two equivalent halves of a scale are correlated to give the split–half reliability coefficient was used. Since the items for each scale were randomly distributed, it was appropriate to correlate the odd–numbered items of a scale with scores on the even–numbered items. In order to correct for underestimation of reliability by this technique, the Spearman–Brown prophecy formula was applied (Borg & Gall, 1989). Their prophecy formula is \( R = \frac{2r}{1 + r} \), where \( R \) is the reliability for the entire test and \( 'r' \) is the reliability for half the test. The advantage of
finding the internal consistency by the split half technique is asserted by Ary and colleagues who said "the method requires only one form of a test, there is no time lag involved, and the same physical and mental influences will be operating on the subjects as they take the two sections (halves)" (Ary, Jacobs, & Razaveih, 1990; p. 276). The internal consistency coefficient (Spearman-Brown) of the NOSS was .40. This was a low reliability for this scale when compared to values reported in the literature. For example, Andersen, et al., (1986) reported a value of .74 for the internal consistency reliability of the NOSS while more recently Cobern (1989) reported a Kuder-Richardson 20 reliability estimate of .71. Kimball (1967) himself reported a value of .72 using the Spearman-Brown split-half formula. These studies also provided validation and field-testing for the NOSS.

Validation of the NSKS is reported by Rubba and Andersen (1978) and some results of field testing have been reported by Lederman (1986) and Mikael (1987). Some evidence of construct related evidence of validity was obtained with the present sample by finding the correlation between the NSKS and scores on its subscales (Table 1). All the subscales were correlated positively and significantly to the total score and thus all were concluded to contribute to the construct "nature of scientific knowledge" (p < .05). The "unified factor" (r = .79) had the highest relationship to the NSKS score and the "creative factor" the least (r = .31). Many correlations among the six factors were modest in magnitude and non-significant as would be expected if they are independent factors. A significantly negative relationship existed between scores on the "creative" subscale and scores on the "amoral" factor (r = -.37 p < .01). While the respondents of this study believed strongly that scientific knowledge was a product of human creativity they also tended to hold that moral judgment could be passed on scientific knowledge, i.e., scientific knowledge was not amoral.

The odd–even split half internal consistency reliability of the NSKS was moderately high (r = .62) but lower than that obtained with comparable samples in previous studies. For example Rubba and Andersen (1978) reported that the reliability as measured by coefficient alphas ranged
from 0.65 with grade nine general science students (n = 101) and 0.88 with college philosophy of science majors (n = 160). Mikael (1987) reported a coefficient alpha \( .88 \) and a test-retest reliability of \( .92 \) with preservice secondary science teachers. Both the NSKS and NOSS appear to be sensitive to sample type and/or to educational levels of respondents.

Table 1. Correlation matrix for the nature of scientific knowledge scale and subscales (n = 59)

<table>
<thead>
<tr>
<th></th>
<th>Overall NSKS</th>
<th>Creative</th>
<th>Amoral</th>
<th>Developmental</th>
<th>Parsimonious</th>
<th>Testable</th>
<th>Unified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall NSKS</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative</td>
<td>.31*</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Amoral</td>
<td>.46**</td>
<td>-.37**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental</td>
<td>.70**</td>
<td>.23*</td>
<td>.12</td>
<td>.18</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parsimonious</td>
<td>.50**</td>
<td>-.09</td>
<td>.17</td>
<td>.18</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testable</td>
<td>.56**</td>
<td>.03</td>
<td>.15</td>
<td>.26*</td>
<td>.19</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Unified</td>
<td>.79**</td>
<td>.14</td>
<td>.29*</td>
<td>.55**</td>
<td>.33**</td>
<td>.35**</td>
<td>1</td>
</tr>
</tbody>
</table>

* Significant at the .05 level.

** Significant at the .01 level

Results

Sample characteristics

The BEd science program comprised of nearly all male teachers (87.30%). Over 95% of all the science teachers were 35 years of age or younger and more than 95% had nine or fewer years teaching experience. The majority (63.49%) had at least one pass in science or mathematics at Advanced level. Advanced level is comparable to grade 13 on the 7-4-2 system of education, i.e., 7 years primary, 4 years basic secondary (junior and ordinary level), and 2 years advanced level. Twenty three had O level (grade 11) qualifications. All of the science teachers except 3 had a certificate in education (CE).
Their academic performance in college and university was average. Just over 50% obtained a "C" grade and around 40% received a "B" grade in all the three major components, teaching practice, theory of education, and science. These are the major areas in which teachers have to pass in order to satisfactorily complete their pre-service teacher preparation. Their performance at the end of Part I of the BEd program showed that approximately 5% scored first division, 18% had upper second division, 45% had lower second division, and 31% were in third division in the five subjects assessed. For the science curriculum theory, a disproportionately large number (43) or 65.15% obtained a third class pass, i.e., their criterion referenced scores lay somewhere between 50% and 59%. This laxity in performance might reflect on the general lack of attention to curriculum issues in pre-service teacher preparation or a poor attitude toward it by the students.

Table 2 shows the correlation matrix for the performance of the respondents in the three sections of the pre-service teacher preparation program and on the five courses in Part I of the BEd program; positive correlations were expected. Fourteen (14) cases with missing data were deleted by the computer program leaving 52 valid cases in the correlation matrix. It was established that for 50 degrees of freedom the critical value of the correlation coefficient was .23 for a one-tailed probability level of .05 and .32 for the .01 significance level (Ary, et al, 1990; Hinkle, et al., 1988). The theory of education (TOE) scores were not correlated to the teaching practice (TP) scores (r = .02) but were modestly but significantly correlated to the teaching subject (MTS) scores (r = .29). The overall performance in the pre-service teacher preparation program was positively and significantly correlated to the overall BEd performance in Part I (r = .30). However, only the teaching subject score (MTS) was significantly correlated to the BEd score (r = .31). Both teaching practice (r = .19) and theory of education (r = .11) scores bore little and non-significant relationship to the BEd score perhaps reflecting the greater emphasis in the science academic content in the degree program.

Scores in the academic courses ESM 101, 102 and 103 were positively and significantly related (p < .01). There was also no relationship between the academic courses ESM 101, 102, and
<table>
<thead>
<tr>
<th></th>
<th>TP</th>
<th>TOE</th>
<th>MTS</th>
<th>ESM 101</th>
<th>ESM 102</th>
<th>ESM 103</th>
<th>ESME 101</th>
<th>ESME 102/201</th>
<th>TTC Score</th>
<th>BEd I Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOE</td>
<td>.02</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTS</td>
<td>.25*</td>
<td>.29*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 101</td>
<td>.27*</td>
<td>.07</td>
<td>.16</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 102</td>
<td>.12</td>
<td>-.01</td>
<td>.26*</td>
<td>.54**</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>ESM 103</td>
<td>.09</td>
<td>.00</td>
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<td>.55**</td>
<td>.60**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESME 101</td>
<td>-.07</td>
<td>.25*</td>
<td>.18</td>
<td>.11</td>
<td>.29*</td>
<td>.26*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESME 102/201</td>
<td>.24*</td>
<td>.12</td>
<td>.23*</td>
<td>.09</td>
<td>.07</td>
<td>.07</td>
<td>.26*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC Score</td>
<td>.60**</td>
<td>.65**</td>
<td>.77**</td>
<td>.24*</td>
<td>.18</td>
<td>.16</td>
<td>.18</td>
<td>.30*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BEd I Score</td>
<td>.19</td>
<td>.11</td>
<td>.31*</td>
<td>.75**</td>
<td>.82**</td>
<td>.80**</td>
<td>.53**</td>
<td>.32*</td>
<td>.30**</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significant at the .05 level.

**Significant at the .01 level.

**Note.**

1. Codes for pre-service teacher preparation scores were: TP = Teaching practice; TOE = Theory of education; MTS = Main teaching subject (Science); and TTC Score = Overall pre-service teacher training college score.

2. Codes for BEd Part I scores were: ESM 101 = Pre-requisite: Chemistry group covered physics and statistics; Biology group covered chemistry and statistics; and Physics group covered mathematics and computing.

ESM 102 = ESMB 102 biology – plant kingdom; ESMC 102 chemistry – introduction to atomic structure and organic chemistry; and ESMP 102 physics – mechanics.

ESM 103 = ESMB 103 biology – animal kingdom; ESMC 103 chemistry – analytical chemistry; and ESMP 103 physics – thermal physics and properties of matter.

ESME 101 = Science Curriculum Theory; ESME 101/201 = Science A level Methods I and II; and BEd I Score = Overall BEd Part I Score.
103 and the A level methods courses ESME 102/201. The A level methods course scores were only modestly but non-significantly correlated to the science curriculum theory course ($r = .26$). In general, the two professional courses do not seem to have a significant relationship with the academic content courses. A factorial analysis of variance technique established that differences in the overall BEd performance scores ($F_{2, 63} = 0.40 p = .67$) or pre-service teacher preparation program scores ($F_{2, 56} = 2.80 p = .07$) did not exist when respondents were grouped according to the science subject in which they specialized.

Forty five (45) teachers or 71.43% of the sample grew up in a religious environment in which both Christianity and traditional religions were practiced. Currently, 42.86% practiced both Christianity and traditional religions, 41.27% Christianity, and 14.28% were non-religious. Nearly 70% grew up in rural areas or in the countryside and the rest grew up at a mining center (23.81%), or in a city (3.17%), or commercial farm (3.17%). Table 3 shows that the majority of the science teachers' parents had some literacy and that the majority, over 68% of mothers and more than 53% of fathers, had received primary level education. More than 80% of the respondents indicated that their mothers were not employed. Twenty seven (42.86%) mothers were reportedly "unemployed" and twenty four (38.09%) were reportedly subsistence farmers, a role which married females have been acknowledged to participate in significantly [Gelfand, 1973]. For comparison, it must be observed that only 17 fathers, i.e., less than 27%, were unemployed or were communal farmers; 46 were employed, 30.16% as general hands (help) and 42.86% were in skilled professional or administrative jobs.

Overall, teachers in the study were relatively young and had appropriate academic and professional qualifications at this point in their careers. They had grown up in home environments where parents had some literacy and practiced religion which combined elements of Christianity and traditional religion. Grades earned in the preservice teacher education program and in Part I of the BEd program suggest that these teachers were of average academic ability.
Table 3. Literacy, education, and employment backgrounds of BEd teachers’ parents (N = 63)

<table>
<thead>
<tr>
<th>Parent Variable</th>
<th>Mother</th>
<th>%</th>
<th>Father</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literacy level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No literacy (unable to read and write)</td>
<td>5</td>
<td>7.94</td>
<td>2</td>
<td>3.17</td>
</tr>
<tr>
<td>Low literacy (just able to read and write)</td>
<td>39</td>
<td>61.90</td>
<td>31</td>
<td>49.21</td>
</tr>
<tr>
<td>High literacy (proficient in reading and writing)</td>
<td>19</td>
<td>30.16</td>
<td>30</td>
<td>47.62</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal education</td>
<td>8</td>
<td>12.70</td>
<td>6</td>
<td>9.52</td>
</tr>
<tr>
<td>Primary education</td>
<td>43</td>
<td>68.25</td>
<td>34</td>
<td>53.97</td>
</tr>
<tr>
<td>Junior secondary (ZJC)</td>
<td>9</td>
<td>14.28</td>
<td>16</td>
<td>25.40</td>
</tr>
<tr>
<td>O Level or Grade 11</td>
<td>2</td>
<td>3.17</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td>Higher education (A level, college or university)</td>
<td>1</td>
<td>1.58</td>
<td>6</td>
<td>9.52</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>27</td>
<td>42.86</td>
<td>1</td>
<td>1.58</td>
</tr>
<tr>
<td>Communal farmer</td>
<td>24</td>
<td>38.09</td>
<td>16</td>
<td>25.40</td>
</tr>
<tr>
<td>Employed, non-skilled or general hand</td>
<td>3</td>
<td>4.76</td>
<td>19</td>
<td>30.16</td>
</tr>
<tr>
<td>Employed, skilled professional or administrative</td>
<td>9</td>
<td>14.28</td>
<td>27</td>
<td>42.86</td>
</tr>
</tbody>
</table>

BEd science teachers' NOSS profiles

Table 4 and Table 5 summarize the profiles of BEd science teachers on Kimball’s nature of science scale. The percentage of respondents “agreeing” or “disagreeing” were obtained by respectively aggregating “strongly agree” and “agree” responses and “strongly disagree” and “disagree” responses. In Table 4, the “% agree” and “% disagree” columns indicate the percentage of respondents who agreed or disagreed with the Kimball model response respectively. For the statements in Table 5, a respondent “agreeing” with the Kimball model is supposed to “disagree” to the statements as written. In both tables, the percentages shown under “uncertain” represent the number of respondents who could not decide whether to agree or to disagree with the statements or model responses; this is the number giving a neutral response. This process enabled the data to be recoded so that the means and standard deviations reported in both Table 4 and Table 5 are based
Table 4. Response profiles of BEd science teachers on positively stated NOSS items (N = 63)\(^a\)

<table>
<thead>
<tr>
<th>Nature of Science Scale Items</th>
<th>% Disagree</th>
<th>% Neutral</th>
<th>% Agree</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Classification schemes are imposed upon nature by the scientists, they are not inherent in the materials classified.</td>
<td>42.86</td>
<td>20.63</td>
<td>36.51</td>
<td>1.90</td>
<td>.89</td>
</tr>
<tr>
<td>10. The ultimate goal of all science is to reduce observations and phenomena to a collection of mathematical relationships.</td>
<td>58.73</td>
<td>15.87</td>
<td>25.40</td>
<td>1.67</td>
<td>.86</td>
</tr>
<tr>
<td>16. Many scientific models are human-made and do not pretend to represent reality.</td>
<td>64.52</td>
<td>16.13</td>
<td>19.35</td>
<td>1.56</td>
<td>.81</td>
</tr>
<tr>
<td>19. The essential test of scientific theory is its ability to correctly predict future events.</td>
<td>28.57</td>
<td>11.11</td>
<td>60.32</td>
<td>2.25</td>
<td>.92</td>
</tr>
<tr>
<td>22. One of the distinguishing traits of science is that it recognizes its own limitations.</td>
<td>12.70</td>
<td>9.52</td>
<td>77.78</td>
<td>2.65</td>
<td>.70</td>
</tr>
<tr>
<td>27. Scientific method is a myth which is usually read into the story after it has been completed.</td>
<td>76.19</td>
<td>12.70</td>
<td>11.11</td>
<td>1.35</td>
<td>.68</td>
</tr>
</tbody>
</table>

\(^{\text{a}}\)Scale is 1 = disagree 2 = neutral 3 = agree.

\(^{\text{b}}\)Total score for entire 29-item scale was significantly lower than the neutral score of 58 (t = -14.38 \(p = .0001\) one tail) and thus respondents did not respond according to the Kimball model responses.

\(^{\text{c}}\)This score is equivalent to a scale rating of 1.67 on the 3-point scale.

on a 3-point scale. A deviation from the "neutral" score, 58 for the entire scale was computed and tested for significance in order to have an indication of whether the teachers' conceptions of the nature of science was adequate or not as recommended by Lederman (1986). The total NOSS score (mean = 48.38 SD = 5.31) was lower and deviated significantly (t = -14.38 \(p = .0001\)) from the neutral index of 58 by 9.62 points. BEd science teachers had inadequate understanding of the nature of science as measured by Kimball's (1967) scale. This total mean score translates to 1.67 on the 3-point scale.
Table 5. Response profiles of BEd science teachers on NOSS items which disagree with Kimball model responses (N = 63)\(^a\)

<table>
<thead>
<tr>
<th>Nature of Science Scale Items</th>
<th>% Disagree</th>
<th>% Neutral</th>
<th>% Agree</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>bTotal NOSS-score</strong></td>
<td>48.38(^c)</td>
<td>5.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The most important scientific ideas have been the result of a systematic process of logical thought.</td>
<td>16.13</td>
<td>6.45</td>
<td>77.42</td>
<td>2.61</td>
<td>.75</td>
</tr>
<tr>
<td>3. Thanks to discovery of the scientific method, new discoveries in science have begun to come faster.</td>
<td>15.87</td>
<td>7.94</td>
<td>76.19</td>
<td>2.60</td>
<td>.75</td>
</tr>
<tr>
<td>4. The primary objective of the working scientist is to improve human welfare.</td>
<td>1.59</td>
<td>4.76</td>
<td>93.65</td>
<td>2.92</td>
<td>.33</td>
</tr>
<tr>
<td>5. While a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is permanent.</td>
<td>20.63</td>
<td>9.52</td>
<td>69.84</td>
<td>2.49</td>
<td>.82</td>
</tr>
<tr>
<td>6. The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator.</td>
<td>66.67</td>
<td>14.29</td>
<td>19.05</td>
<td>1.52</td>
<td>.80</td>
</tr>
<tr>
<td>7. Science is constantly working toward more detailed and complex knowledge.</td>
<td>12.70</td>
<td>7.94</td>
<td>79.37</td>
<td>2.67</td>
<td>.70</td>
</tr>
<tr>
<td>8. A fundamental principle of science is that discoveries and research should have some practical applications.</td>
<td>6.45</td>
<td>1.61</td>
<td>91.94</td>
<td>2.85</td>
<td>.51</td>
</tr>
<tr>
<td>9. While biologists use the deductive approach to a problem, physicists always work inductively.</td>
<td>30.16</td>
<td>30.16</td>
<td>39.68</td>
<td>2.09</td>
<td>.84</td>
</tr>
<tr>
<td>11. The best definition of science would be an &quot;organized body of knowledge&quot;.</td>
<td>36.51</td>
<td>12.70</td>
<td>50.79</td>
<td>2.14</td>
<td>.93</td>
</tr>
<tr>
<td>12. Science tries mainly to develop new machines and processes for the betterment of humankind.</td>
<td>6.35</td>
<td>0.00</td>
<td>93.65</td>
<td>2.87</td>
<td>.49</td>
</tr>
<tr>
<td>13. Any scientific research broader than a single specialist can only be carried out through the use of a team of researchers from various relevant fields.</td>
<td>20.63</td>
<td>7.94</td>
<td>71.43</td>
<td>2.51</td>
<td>.82</td>
</tr>
</tbody>
</table>

\(^a\)Scale is 1 = disagree 2 = neutral 3 = agree.

\(^b\)Total score for entire 29-item scale was significantly lower than the neutral score of 58 (t = -14.38 p = .0001 one tail) and thus respondents did not respond according to the Kimball model responses.

\(^c\)This score is equivalent to a scale rating of 1.67 on the 3-point scale.
### Table 5. (continued)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong.</td>
<td>76.19</td>
<td>9.52</td>
<td>14.29</td>
<td>1.38</td>
</tr>
<tr>
<td>15. Team research is more productive than individual research.</td>
<td>14.52</td>
<td>17.74</td>
<td>67.74</td>
<td>2.54</td>
</tr>
<tr>
<td>17. Scientific investigations follow definite approved procedures.</td>
<td>30.16</td>
<td>7.94</td>
<td>61.90</td>
<td>2.32</td>
</tr>
<tr>
<td>18. Most scientists are reluctant to share their findings with foreigners, being mindful of the problem of national security.</td>
<td>49.21</td>
<td>14.29</td>
<td>36.51</td>
<td>1.87</td>
</tr>
<tr>
<td>20. When a large number of observations have shown results consistent with a general rule, this generalization is considered to be a universal law of nature.</td>
<td>4.84</td>
<td>8.06</td>
<td>87.10</td>
<td>2.82</td>
</tr>
<tr>
<td>21. The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it.</td>
<td>6.35</td>
<td>0.00</td>
<td>93.65</td>
<td>2.87</td>
</tr>
<tr>
<td>23. The steam engine was one of the earliest and most important developments of modern science.</td>
<td>12.90</td>
<td>8.06</td>
<td>79.03</td>
<td>2.66</td>
</tr>
<tr>
<td>24. Scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning.</td>
<td>4.76</td>
<td>1.59</td>
<td>93.65</td>
<td>2.89</td>
</tr>
<tr>
<td>25. If at some future date it is found that electricity does not consist of electrons, today's practices in designing electrical apparatus will have to be discarded.</td>
<td>77.78</td>
<td>14.29</td>
<td>7.94</td>
<td>1.26</td>
</tr>
<tr>
<td>26. By application of the scientific method, step by step, humans can solve almost any problem or answer any question in the realm of nature.</td>
<td>33.33</td>
<td>9.52</td>
<td>57.14</td>
<td>2.24</td>
</tr>
<tr>
<td>28. Scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work.</td>
<td>57.14</td>
<td>7.94</td>
<td>34.92</td>
<td>1.78</td>
</tr>
<tr>
<td>29. An important characteristic of the scientific enterprise is its emphasis on the practical.</td>
<td>1.59</td>
<td>3.17</td>
<td>95.24</td>
<td>2.93</td>
</tr>
</tbody>
</table>
Further analysis of the data in Table 4 and Table 5 was done to explore perceptions of respondents in relation to individual model points and to items based on the model points in Figure 1. Their understanding was adequate on only 6 of the 29 items (items, 6, 14, 19, 22, 25, & 28). Seven items (4, 8, 12, 23, 24, 25, & 29) in Table 4 were based on the model point # 1 (Figure 1). A clear majority of the respondents, 79% or more, disagreed with this model point as expressed in statements 4, 8, 12, 23, 24, and 29. They believed that the driving force of science had connections with outcomes, applications, or uses. Over 93% were clearly affirmative to item 12, 4, and 24 which asserted respectively that science tries to develop new machines for the betterment of mankind, science tries to improve human welfare, and that science should be given credit for producing such things as modern refrigerators, television, and home air conditioning. Almost 92% believe that scientific discoveries should have practical applications (item 8). BEd science teachers associated science with practical applications and with the development or production of useful technology.

Barely over 50% agreed with model point # 2 (item 11) which depicted science as "process oriented, dynamic, on going activity rather than a static accumulation of information"; 36.51% disagreed and 12.76% were neutral. This sample of teachers did not view science as parsimonious (model point # 3) as measured on two items (7 and 10). Almost 80% believed that "science is constantly working toward detailed and complex knowledge" and 58.73% disagreed that "the ultimate goal of all science is to reduce observations and phenomena to a collection of mathematical relationships". A majority of respondents, 61% or more, agreed with six of the statements (1, 3, 13, 15, 17, and 21) and thus disagreed with model point # 4 that "there are many methods of science". More than 93% believed that the scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it (item 21). Nearly 62% believed that scientific investigations follow definite approved procedures (item 17) and thus believed that there was a single scientific method. Three items, 2, 16, and 19 were based on model point 5 which depicted science as characterized by a few attributes such as
dependence upon sense experience, use of operational definitions, arbitrariness of definition, and schemes of classification or organization, etc. Only 42.86% of the respondents were affirmative that classification schemes are "not inherent in the materials classified" (item 2). Nearly 65% disagreed that scientific models are human-made and "do not pretend to represent reality" (item 16). Nearly 60% accepted statement 19 that "the essential test of a scientific theory is its ability to correctly predict future events". BEd science teachers did not possess definitive understanding of the use of models and/or the role and arbitrariness of classification schemes in science.

A significant majority (> 66%) of the respondents agreed with model point # 6 asserting that "a basic characteristic of science is faith in the susceptibility of the physical universe to human ordering and understanding" (items 6 and 14). Nearly 67% disagreed with statement 6 "the scientific investigation of human behavior is useless because it is subject to the unconscious bias of the investigator". Three quarters (76.18%) disagreed with assertion 14 "investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong". A lone item 18 which raised the issue of scientists and nationalism was based on model point # 7 "science has a unique attribute of openness of mind, allowing for willingness to change in the face of evidence, and the openness of the realm of investigation, unlimited by such factors as religion, politics or geography". Its mean score of 1.87 (SD = 0.92) was not significantly different from the neutral value of 2. Nearly half (49%) of the respondents disagreed that "most scientists are reluctant to share their findings with foreigners, being mindful of the problem of national security". The other half of the sample were either uncertain (14.29%) or agreed with the statement (36.50%).

Model point # 8 "tentativeness and uncertainty mark all of science" was assessed by four statements 5, 20, 22, and 26. A significant majority disagreed with the model. For example, 69.84% and 87.10% respectively agreed with the statement 5 and statement 20 which read, respectively, "while a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is permanent" and "when a large number of observations have shown results consistent
with a general rule, this generalization is considered to be a universal law of nature”. All the scores except that for item 22 (mean = 2.65 SD = 0.70) were significantly lower than the neutral index of 2.00 (p < .05). Teachers in this sample did not adequately view scientific knowledge as tentative and in fact viewed "laws" as permanent and unchangeable generalizations.

Comparison of NOSS profiles for Zimbabwean, Nigerian and American samples

Comparison of these findings 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). Comparison samples comprised of pre-service senior secondary science teachers in Nigeria in 1983 (n = 32) (Cobern, 1989) and pre-service secondary teachers in the USA the majority of whom had already earned a bachelor's degree in 1984 (n = 21) (Andersen, et al., 1986). All scores were based on a 3-point scale. The three sample mean total NOSS scores were compared using the t-test for unequal groups with unequal variances to evaluate for statistical significance. The standard error of differences hence the t-value and the number of degrees of freedom were estimated using, respectively, the Cochran and Cox formula and the Satterthwaitte procedure (Hinkle, et al., 1988; p. 251).

USA preservice teachers had significantly higher NOSS scores compared to either Zimbabwean or Nigerian sample of science teachers. Cobern (1989) observed that the Nigerian sample had significantly lower NOSS scores compared to the American sample (mean difference (d) = - 8.60 t = - 4.09 p < .05). In this study, the Zimbabwean sample NOSS score of 48.38 is not significantly different from that of the Nigerian sample (mean = 49.50) (t = - 0.75 df = 46 p > .05) but is significantly lower than that of the American sample (mean = 58.10) (d = - 9.72 t = - 5.63 df = 27 p < .05). Although the order of magnitude of the mean scores was in the order USA>Nigeria>Zimbabwe the Spearman rank correlation coefficients of the three samples were significantly positive (p < .01): .93 for the Nigerian and Zimbabwean samples and .69 for 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.
Table 6 shows an extract of the NOSS items on which the American respondents differed from the Zimbabwean sample by at least ± 0.5 points. A difference in mean scores, i.e., the "d-score" (Table 6) of 0.5 or higher was considered as the minimum difference for practical significance (Cobern, 1989). Using this strategy it was established that the Zimbabweans and Americans differed on 9 NOSS items and that the Zimbabweans and Nigerians did not differ by more than 0.5 points. The Nigerian sample was found to be significantly different from the American sample on 8

Table 6. Comparison of NOSS profiles for Zimbabwean and American samples

<table>
<thead>
<tr>
<th>Item and Model Responsea</th>
<th>Zimbabwe (n = 63)</th>
<th>American (n = 21)</th>
<th>bD- Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Z)c</td>
<td>s²</td>
<td>Mean (A)</td>
</tr>
<tr>
<td>Total NOSS-score</td>
<td>48.38</td>
<td>28.18</td>
<td>58.10</td>
</tr>
<tr>
<td>4. The primary objective of the working scientist is to improve human welfare.</td>
<td>1.08</td>
<td>0.11</td>
<td>1.60</td>
</tr>
<tr>
<td>5. While a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is permanent.</td>
<td>1.51</td>
<td>0.67</td>
<td>2.10</td>
</tr>
<tr>
<td>8. A fundamental principle of science is that discoveries and research should have some practical applications.</td>
<td>1.15</td>
<td>0.26</td>
<td>2.00</td>
</tr>
<tr>
<td>9. While biologists use the deductive approach to a problem, physical always work inductively.</td>
<td>1.90</td>
<td>0.70</td>
<td>2.40</td>
</tr>
<tr>
<td>12. Science tries mainly to develop new machines and processes for the betterment of humankind.</td>
<td>1.13</td>
<td>0.24</td>
<td>2.20</td>
</tr>
<tr>
<td>13. Any scientific research broader than a single specialist can only be carried out through the use of a team of researchers from various relevant fields.</td>
<td>1.49</td>
<td>0.67</td>
<td>2.30</td>
</tr>
<tr>
<td>20. When a large number of observations have shown results consistent with a general rule, this generalization is considered to be a universal law of nature.</td>
<td>1.18</td>
<td>0.25</td>
<td>1.80</td>
</tr>
<tr>
<td>23. The steam engine was one of the earliest and most important developments of modern science.</td>
<td>1.34</td>
<td>0.49</td>
<td>2.30</td>
</tr>
<tr>
<td>29. An important characteristic of the scientific enterprise is its emphasis on the practical.</td>
<td>1.06</td>
<td>0.09</td>
<td>2.10</td>
</tr>
</tbody>
</table>

a Only the NOSS-items for which a mean difference of 0.5 or greater are shown.

b This is a deviation score obtained by subtracting the Zimbabwean score from the American sample score.

c The Zimbabwean mean total score was significantly lower than that for the American sample (t_{df 27} = - 5.63 p < .05). The mean total score of the Zimbabwean sample was also significantly less like the Kimball model response score.
items as reported by Cobern (1989; p. 537); the items on which they differed are basically the same NOSS items on which the Americans scored differently than the Zimbabwean sample (Table 6). An analysis of variances showed that the Zimbabwean sample had significantly lower variability ($s^2 = 28.18$) compared to either Nigerians ($s^2 = 57.76$ $F_{31,62} = 2.05$ $p < .05$) or American samples ($s^2 = 53.29$ $F_{20,62} = 1.89$ $p < .05$). The demographic profiles of the Zimbabweans suggested that they were a fairly homogenous sample and this homogeneity might be reflected in the variance of their NOSS scores.

Zimbabwean teachers compared to their American counterparts tended to agree less with all Kimball model responses. For example, significant and practical differences were found in their responses concerning model #1 "openness of science". This was evident as shown by significant differences on items 4, 8, 12, 23, 25, and 29, i.e., six of seven items discriminate between the two groups. Like the Nigerian sample in the Cobern (1989), the Zimbabwean teachers in this study were more inclined than American pre-service teachers to view science in technological and developmental terms; they tend to perceive the nature of science in terms of its capability to produce useful technology or to improve human welfare. Zimbabwean teachers were more likely than the American teachers to accept that "the best definition of science would be an organized body of knowledge". Significant differences between Zimbabwean and American responses were also detected for items 5, 20, and 22, i.e., on model point # 8 "tentativeness and uncertainty mark all of science". The two groups also differed significantly on items 9, 13, and 15 (model # 4) which asserted that "there is no one scientific method". The Zimbabwean sample was more likely than the American sample to perceive that there was a single scientific method which had a determinate number of steps. Zimbabwean teachers believed more than Americans that scientists were nationalistic and secretive in their work (model point 7, item 18). They did not differ significantly on their view of the "parsimony" nature of science; they differed only modestly on model point 6 which asserted the susceptibility of the physical universe to human ordering and understanding.
Internal replication of the study was accomplished by simultaneously administering the Rubba and Andersen (1978) nature of scientific knowledge scale (NSKS). Table 7 shows the scores obtained on the NSKS and its six subscales. It also summarizes the results of testing whether their scores deviated significantly from the neutral index following the Lederman (1986) rationale. In Table 7 and in Table 8 each of the NSKS scores has been converted to its five-point scale equivalent to make it easier to see how respondents rated items and constructs relative to the instrument scale. The total NSKS score (mean = 168.81 SD = 12.86) deviated from the neutral index of 144 significantly by 24.81 points (t = 15.18 p < .0001). BEd science teachers' in this sample had an "adequate" conception of the nature of scientific knowledge contradicting the results obtained with Kimball's NOSS.

Table 7. BEd science teachers' conception of the nature of scientific knowledge (n = 63)

<table>
<thead>
<tr>
<th>Subscale/Scale</th>
<th>Mean^</th>
<th>S.D.</th>
<th>d-Score^</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total NSKS</td>
<td>168.81</td>
<td>12.86</td>
<td>24.81</td>
<td>15.18***</td>
<td>.0001</td>
</tr>
<tr>
<td>Amoral</td>
<td>25.11</td>
<td>4.63</td>
<td>1.11</td>
<td>1.88*</td>
<td>.0324</td>
</tr>
<tr>
<td>Creative</td>
<td>27.61</td>
<td>4.57</td>
<td>3.61</td>
<td>6.22***</td>
<td>.0001</td>
</tr>
<tr>
<td>Developmental</td>
<td>28.59</td>
<td>4.06</td>
<td>4.59</td>
<td>8.82***</td>
<td>.0001</td>
</tr>
<tr>
<td>Parsimonious</td>
<td>24.62</td>
<td>3.47</td>
<td>0.62</td>
<td>1.37</td>
<td>.0872</td>
</tr>
<tr>
<td>Testable</td>
<td>32.22</td>
<td>3.86</td>
<td>8.22</td>
<td>16.76***</td>
<td>.0001</td>
</tr>
<tr>
<td>Unified</td>
<td>30.69</td>
<td>3.67</td>
<td>6.69</td>
<td>14.35***</td>
<td>.0001</td>
</tr>
</tbody>
</table>

* Significant at the .05 level.
*** Significant at the .0001 level.

^The numbers in parentheses are the score equivalents on the 5–point scale.

^The d-score is the deviation score obtained by subtracting neutral score for that scale or subscale from its scale or subscale score. The neutral score is obtained by multiplying the number of items in that scale or subscale by a value of 3.
For all the subscales the BEd science teacher sample scored higher than the neutral index of 24. The "amoral" factor score of 25.11 was modest but significantly higher than the neutral score index of 24 (t = 1.88 p = .0324). Scores on five of the 8 "amoral" items were no different from a neutral conception. For example, respondents were split (45.17% disagreeing and 46.77% agreeing) with the statement "it is incorrect to judge a piece of scientific knowledge as being good or bad". BEd science teachers in this study appear to be uncertain whether scientific knowledge can be judged good or bad, i.e., whether or not it is amoral. BEd science teachers' conception of scientific knowledge as a product of human creativity was adequate (mean = 27.61 t = 6.22 p < .0001). However, nearly 70% of the respondents believed that scientific theories were discovered and not created by humans. Just over 54% agreed to the statement "scientific knowledge is not a product of human imagination" and a comparable proportion (53.23%) agreed to its reverse item "scientific knowledge is a product of human imagination". This response pattern raises doubt as to whether science teachers in the study had an adequate conception of the creative factor.

BEd science teachers also had an adequate understanding of the developmental or tentative nature of scientific knowledge (mean = 28.59 t = -8.82 p = .0001). However, respondents were neutral to 3 of the 8 items making up the "tentative" factor, e.g., they were divided in their response regarding acceptance of scientific knowledge if it contained error. For example, 46.77% respectively agreed and disagreed on item 16 "we accept scientific knowledge even though it may contain error"; 48% accepted or were uncertain on the assertion "we do not accept a piece of scientific knowledge unless it is free of error". They were also split, 45.17% agreeing and 43.54% disagreeing to the statement asserting that "the truth of scientific knowledge is beyond doubt". Their response profiles on these 3 items lead to the speculation that a substantive number of teachers in the sample believed scientific knowledge to be absolutely true and error free. Further, the science teachers did not view scientific knowledge as parsimonious (mean = 24.62 t = 1.37 p = .09). About 60% disagreed that "there is an effort in science to keep the number of laws, theories and concepts at a minimum" and nearly 63% believed the reverse statement "there is an effort in science to build as great a
number of laws, theories and concepts as possible". Their responses to the rest of the items were consistent with a perception of scientific knowledge as non-parsimonious. This finding corroborates that obtained on the NOSS. For example, 50% believed that "scientific knowledge is specific as opposed to comprehensive" to which a comparable number (48.33%) disbelieved when stated conversely. This sample believed also that scientific knowledge should be capable of empirical testing (mean = 32.22 t = 16.76 p < .0001) and the teachers were consistent in their belief that scientific knowledge was unified, i.e., the various specialized sciences contribute to an interrelated network of laws, theories and concepts (mean = 30.69 t = 14.35 p< .0001).

International comparison of scientific knowledge profiles

The nature of scientific knowledge profiles of Zimbabwean teachers were compared to the data of 18 American high school biology teachers in the state of New York (Lederman, 1986) with the results in Table 8. Comparisons were made with the t-test for unequal group and unequal variance independent samples with appropriate corrections for standard error of differences and degrees of freedom made using, respectively, the Cochran and Cox formula and the Satterthwaite procedure (Hinkle, et al., 1988; p. 251). Lederman's sample scored higher than the neutral position on every NSKS scale while the Zimbabwean teachers scored higher than neutral on all but the parsimonious scale. The Lederman sample also scored consistently and significantly higher NSKS scores on every scale compared to the Zimbabwe sample in this study. Zimbabwe teachers demonstrated less adequate conceptions of the nature of scientific knowledge when compared to American biology teachers. This finding must be interpreted cognizant that the American sample consisted of teachers who had relatively more teaching experience, had already attained an undergraduate degree level academic qualification, and were from a western culture where science and its values are articulated relatively more in everyday life.
Table 8. Conception of the nature of scientific knowledge profiles of Zimbabwean and American science teachers

<table>
<thead>
<tr>
<th>Scale/Subscale</th>
<th>Zimbabwe (n = 63)</th>
<th>USA Sample (n = 18)</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean b</td>
<td>s²</td>
<td>Mean c</td>
</tr>
</tbody>
</table>

* Significant at the .05 level.
** Significant at the .01 level.

a Comparison data obtained from Lederman (1986; p. 95).
b, c The numbers in parentheses are the score equivalents on the 5-point scale.
d Z - A represents the difference scale or subscale score between samples.
e The t-value and the number of degrees of freedom in parentheses were obtained via the Cochran and Cox and the Satterthwaitte formula respectively (Hinkle, et al., 1988; p. 251).

Relationship between Kimball’s NOSS and Rubba-Andersen’s NSKS

The results of this study suggest that the two scales, NOSS and NSKS, were able to discriminate between American and Zimbabwean subjects. However, the BEd science teachers demonstrated inadequate conceptions of the Kimball nature of science and adequate conceptions of the nature of scientific knowledge on the Rubba and Andersen scale. The hypothesis that the composite score on the NOSS was positively correlated to the composite score and the subtest scores on the NSKS was rejected. According to the data in Table 9, the NOSS score was not related to the NSKS score (r = .02) and to four of the NSKS subscales depicting the amoral, developmental, parsimonious, and the unified nature of scientific knowledge. A significant negative relationship
existed between the NOSS and the "creative" subscale \((r = -0.27 \ p < 0.05)\) but the relationship between the NOSS score and the testable scale was positive \((r = 0.29 \ p = 0.05)\). These findings may suggest that the two scales are independent and were perceived by this sample to measure different aspects of the construct "nature of science". The NOSS statements tended to reflect the characteristics of "scientific activity" (NOSS) as opposed to the characteristics of scientific knowledge so generated (measured on the NSKS).

**Teacher characteristics and conception of the nature of scientific knowledge**

The analysis of variance technique (ANOVA) was used to explore differences that may exist in the science teachers' perceptions based on differences among levels of factors such as area of specialization, sex, teaching experience, academic and professional qualifications, and the sociocultural variables. No significant differences \((p > 0.05)\) were found in the BEd science teachers' perception of the nature of science or scientific knowledge when grouped according to the factors: subject specialization, gender, age group, academic qualifications, teacher training program, professional qualifications, teaching experience, pre-service training college, vernacular language

Table 9. Relationship between BEd science teachers' scores on the nature of science scale (NOSS) and on the nature of scientific knowledge scale (NSKS) \((n = 59)\)\(^a\)

<table>
<thead>
<tr>
<th>NSKS</th>
<th>Creative</th>
<th>Amoral</th>
<th>Developmental</th>
<th>Parsimonious</th>
<th>Testable</th>
<th>Unified</th>
<th>NOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amoral</td>
<td>0.31*</td>
<td>-0.37**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental</td>
<td>0.70**</td>
<td>0.24*</td>
<td>0.12</td>
<td>0.17</td>
<td>0.18</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Parsimonious</td>
<td>0.50**</td>
<td>-0.09</td>
<td>0.15</td>
<td>0.26*</td>
<td>0.19</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Testable</td>
<td>0.59**</td>
<td>0.14</td>
<td>0.29*</td>
<td>0.55**</td>
<td>0.33**</td>
<td>0.35**</td>
<td>1</td>
</tr>
<tr>
<td>Unified</td>
<td>0.79**</td>
<td>0.03</td>
<td>0.15</td>
<td>0.26*</td>
<td>0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOSS</td>
<td>0.02</td>
<td>-0.27*</td>
<td>-0.07</td>
<td>-0.08</td>
<td>0.08</td>
<td>0.29*</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*Significant at .05 level.

**Significant at .01 level.

\(^a\) Sample size \(n = 59\) because 4 missing cases were deleted.
spoken, 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.

**Relationship of science teachers' nature of science profiles to other constructs**

The relationships among BEd science teachers' nature of science profiles, environmental conservation awareness, instructional ideology preference, and orientation towards indigenous culture are summarized in Table 10. The individual correlations 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 (Table 10) the following observations can be made about

Table 10: Correlation among BEd science teachers' scores on the nature of science, instructional ideology, environmental-conservation, and cultural orientation

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>NSKS</th>
<th>ECAS</th>
<th>SPT</th>
<th>SPI</th>
<th>NOSS</th>
<th>OICS</th>
<th>TTC</th>
<th>BED</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSKS</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECAS</td>
<td>.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPT</td>
<td>.18</td>
<td></td>
<td>.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td>-.12</td>
<td>.30*</td>
<td>-.22</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOSS</td>
<td>-.00</td>
<td>.27*</td>
<td>-.44**</td>
<td>.05</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OICS</td>
<td>-.05</td>
<td>-.22</td>
<td>.40*</td>
<td>-.03</td>
<td>-.07</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC</td>
<td>-.06</td>
<td>.04</td>
<td>.06</td>
<td>.02</td>
<td>.08</td>
<td>.15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BED</td>
<td>-.03</td>
<td>-.18</td>
<td>.23*</td>
<td>-.07</td>
<td>-.23*</td>
<td>.08</td>
<td>.27*</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significant at p ≤ .05.

**Significant at p ≤ .01.

a Sample size n = 58 because 5 missing cases deleted.

b Abbreviations for constructs in the study were as follows:

NSKS = nature of scientific knowledge score; ECAS = environmental conservation awareness score; SPT = preference for inquiry instructional ideology score; SPI = preference for traditional instructional ideology score; NOSS = nature of science score; OICS = orientation to indigenous culture score; TTC = pre-service teacher training score; and BED = BEd Part I score.
relationships among the five constructs in the study. A modest and non-significant negative correlation was found between the orientation to indigenous culture scores and either the environmental conservation scores, nature of scientific knowledge scores, instructional preference for inquiry scores, or the nature of science scores. A significant positive relationship was obtained between orientation to indigenous culture scores and instructional preference for traditional non-inquiry scores ($r = .40$ $p < .01$). Both an orientation toward indigenous culture and a preference for traditional methods of instruction was supposed to reflect, relatively, a degree of authoritarianism. A positive and significant relationship was observed between the teachers’ environmental conservation awareness scores and the instructional preference for inquiry and nature of science scores. Another interesting finding in the data in Table 10 is the lack of significant relationship between pre-service teacher training scores and between BEd Part I scores and constructs of the study. There was also no substantive relationship between socio-cultural and academic or professional background variables and the nature of science or the other dependent variables measured in the broader study. This could probably be due to the relative homogeneity of the sample.

**Summary, discussion, and conclusion**

The data presented suggest that the teachers in this sample did not adequately view science in terms of the model responses put forward by Kimball (1967). However, an attempt to internally replicate the study revealed that they had an adequate understanding of the nature of scientific knowledge as interpreted on the Rubba and Andersen (1978) model. A surprising finding was the complete lack of relationship ($r = .00$) between nature of scientific knowledge (NSKS) and the nature of science scores (NOSS). This could be interpreted to imply that the two constructs simply represent independent models of the nature of science; items used to measure broad areas of the nature of science may not be related to items that measure specific areas of the nature of science. In this case the Kimball nature of science scale (NOSS) measures broad aspects of the nature of science “activity” (Doran, et al., 1974) while Rubba and Andersen's (1978) NSKS measures a spe-
cific dimension "nature of scientific knowledge". The NOSS measures the understanding of the nature of scientific activity while the NSKS measures understanding of the nature of scientific knowledge or the product of scientific activity. Even then some correlation was to be expected as scientific activity and scientific knowledge are not completely independent. This finding Meichtry’s (1993) speculation that adequate conceptions on one model of the nature of science may not be found with another model which suggests that profiles of conceptions of the nature of science can be inconsistent.

BEd science teachers were found to have an inadequate understanding of some pertinent aspects of the nature of science and scientific knowledge. They did not believe that scientific knowledge was parsimonious and were uncertain whether it was amoral or not. On the NOSS, overall, this sample of science teachers associated science with practical applications and with the development or production of useful technology. On this aspect their perception was similar to that of a Nigerian sample of pre-service science teachers reported by Cobern (1989). Both African samples were more inclined than American pre-service teachers to perceive the nature of science in terms of its capability to produce useful technology or to improve human welfare. BEd science teachers did not see scientific knowledge as parsimonious and they perceived of a single scientific method with a determinate number of procedural steps; they did not possess a definitive understanding of the use of models and/or the role classification schemes in science. More than 66% had an inadequate understanding of the tentativeness of scientific knowledge; they seemingly viewed "laws" as permanent and unchangeable generalizations.

Although the reliability coefficient of the scales were low with this sample, teachers' ratings were consistently lower than those of American teachers to whom they were compared. The Zimbabweans tended to have consistently lower scores and of concern is the observation that they accepted the view of science as an organized body of knowledge and believed in a single scientific method which had a determinate number of steps. Before the findings can be generalized beyond these samples, it must be conjectured that the observed differences can probably be explained by
curriculum differences. The findings concerning the Zimbabwean sample should be of concern because the teachers were already half-way through their inservice training program. They also had completed successfully the teaching methods and science curriculum theory which are said to be the courses which should deal with philosophical aspects of the nature of science (Akindehin, 1988).

However, the personal, socio-cultural, and professional variables theorized to be related to or which were thought to account for differences in ratings were not found to do so. This finding appears to corroborate the findings of two studies, Lavach (1969) and Carey and Stauss (1970) (both cited in Lederman, 1992), which found no relationship between the nature of science scores and teachers' academic variables, teaching experience, subjects taught, subject major, and others. The BEd teachers' scores on the pre-service teacher preparation program a few years back and scores in Part I of the BEd program four months prior bore no meaningful relationship to the teachers perception of the nature of science. It is therefore possible that misconceptions and depressed scores on the nature of science and scientific knowledge could be accounted for by the nature of the science teacher education curricula and programs. These emphasize the structure and content of the academic disciplines and fail to incorporate substantive considerations of the philosophical aspects of the nature of science. In this study only the teaching subject score in the preservice program was significantly correlated to the BEd Part I score \(r = .31\). In the BEd program the two professional courses, Science Curriculum Theory and A Level Science Methods, did not have a significant relationship with the academic content courses in science. The socio-economic context of Zimbabwe as depicted in the national policy documents and curricula interchange acquisition of scientific world-view with modernism and with social and economic development. The national expectation for science and technology to improve material and technological condition of the nation is manifest in the BEd science teachers' perceptions of the nature of science.

It is necessary to take heed of the potential consequences this might have in education. 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 "lopsided approach to making decisions about environmental and technological issues" (p. 413). Cobern (1989) notes that acceptance of science in "development" can raise unrealistic expectations for science since there is more to technological development than just a scientific base. Science could be rejected in the future when the public finds that science fails to deliver satisfactory solutions to emergent societal issues. This sample of 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. Odhiambo (1968) once noted this danger of Africans appreciating technological products or technological aspects of science while remaining perplexed by the "inner spirit of science". Science can easily be treated as a technology or as a set of procedures and rules which then limits "the understanding of science to the facility with which one can regurgitate facts" (Odhiambo, 1968; p. 39).

It should be noted also that their conceptions of the nature of science could reflect a lack of awareness of the history and philosophy of science. The Bed science teachers had a simplistic, superficial, and naive notion of the nature of science; items requiring abstraction and reflection on science as a constructive process were rated negatively compared to items which depicted science as fact. At least 68% BEd teachers agreed with 15 of the 23 NOSS items they were supposed to disagree with. For example, they lacked awareness of the arbitrariness of classification schemes and definitions. They did not conceive that "many scientific models are human-made and do not pretend to represent reality" (about 65% disagreed to this item). More than 77% agreed that the most important scientific ideas have been the result of a "systematic process of logical thought" possibly reflecting a lack of awareness of the history of science. This apparent lack of awareness of the history of science perhaps explains the naive linkage between the scientific method and discoveries. For example, just over 76% believed that new discoveries are linked to the direct application of the scientific method. About 62% agreed that "scientific investigations follow
definite approved procedures" and almost 60% believed that "by application of the scientific
method, step by step, humans can solve almost any problem...".

Some conceptions of the nature of science the teachers had suggest a possibility that a
situation could be present in classrooms where science is presented as authoritarian, fixed,
unchangeable, and non-tentative. In this study BEd science teachers had substantial preference for
traditional non-inquiry instructional ideology. They also had authoritarian views concerning the
nature of science which they conceived as non-tentative and a fixed body of knowledge amassed via
"the scientific method". This, as other researchers have noted, could potentially lead to
overemphasis of content at the expense of processes of science (Cobern, 1989). Their orientation or
commitment toward indigenous traditional culture had a significant positive relationship to
preference for non-inquiry ideology and a negative relationship to a preference for inquiry
instructional ideology. Certainly further research is necessary to better understand teacher beliefs
concerning the nature of science and indigenous culture and how these beliefs manifest themselves in
local classrooms as well as how science teacher education can best prepare teachers for a
traditional world-view dominated non-western socio-cultural context. This study demonstrated
that there was a discrepancy between views of science held by science teachers and those expressed
in accepted models of the nature of science.

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CHAPTER VII. ASSESSMENT OF SECONDARY SCIENCE TEACHERS' AWARENESS OF A SCIENCE-TECHNOLOGY-SOCIAL ISSUE RELATIVE TO KNOWLEDGE OF THE NATURE OF SCIENCE, INSTRUCTIONAL IDEOLOGY, AND TO ORIENTATION TOWARDS TRADITIONAL CULTURE IN ZIMBABWE

Paper to be submitted to the Transactions of the Zimbabwe Scientific Association

Overson Shumba

Abstract

This article describes the results of a study which measured and interpreted 63 secondary science teachers' awareness of a science-technology-related societal issue relative to understanding of the nature of science and scientific knowledge, to instructional ideology preference, and to their level of commitment toward traditional culture in Zimbabwe. The science teachers were enrolled in the BEd degree program at the University of Zimbabwe in 1994. Their awareness of a societal issue, environmental-conservation, was substantial and at a socially acceptable level. Their profiles of environmental-conservation indicated that they were pessimistic about the ability and desirability of science and technology to resolve environment or conservation related problems; but they identified positively with items requiring taking personal responsibility to resolve environmental-conservation issues. The teachers' environmental-conservation profiles were interpreted in relation to their understanding of the nature of science and scientific knowledge, instructional ideology, and to their level of commitment to indigenous cultural beliefs.

Background

Internationally, the impact of science and technology on society and the environment is increasingly putting pressure on nations to ensure that all their citizens acquire some knowledge about science and technology to serve as a basis to debate, decide, and vote on science and technology
related societal issues. This expectation for science education to be concerned with citizenship preparation generally accounts for the emergence of science–technology–society (STS) courses. In STS, the acquisition of scientific literacy is defined to include the development of an awareness of the social implications of science and technology and the attainment of socially and environmentally responsible attitudes (Yager, 1993). STS seeks to develop an understanding about how science, technology, and society influence one another and knowledge about how to use such knowledge in everyday decision making (Brunkhorst & Yager, 1990). Many science education reform efforts are increasingly concerned with how to stir students toward utilizing science for improving their own lives, for coping with an increasingly technological world, for dealing responsibly with science–related societal issues, and for sustaining an interest in science and technology related careers as recommended in Project Synthesis (Harms & Yager, 1981).

The need for such a societal issue oriented approach in science education is necessitated, first, by the need to humanize the curriculum so that it can be perceived as relevant and responsive to individual as well as to societal needs and, second, by the need to narrow the widening gap between the scientifically literate and ordinary citizens. For example, barely a decade ago the National Commission on Educational Excellence (1983) in the United States warned of "a growing chasm between a small scientific and technological elite and a citizenry of ill-informed, indeed uninformed, on issues with a science component" (p. 10). A similar assertion was made more than three decades ago when Snow (1961) described "the gulf of mutual incomprehension" which existed between the scientifically literate and the non–scientifically literate. He said "they have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can’t find much common ground" (Snow, 1961; p. 4). A "common ground" for scientists and non–scientists concerns the preservation and conservation of the bio–physical environment and resource–conservation so that the quality of life is sustained or improved. Steiner (1973) explains:

One identified area of societal concern with which we are typically confronted is that of man's [sic] total position in nature, especially as a result of his science and technology. This area includes such specific issues as man's utilization of natural resources, the population of
the world, the pollution of the earth's environment, and the applications of technology. These and other issues are increasingly being linked directly or indirectly with science and technology, and therefore they must be regarded with more than passing interest by science educators. (p. 417)

Along similar lines the Council for Environmental Quality (1992) in the USA advised that environmental educators should instill among young people an environmental ethic which will prepare them to deal responsibly with environmental issues throughout their lives and that they should raise the environmental awareness of adults as informed consumers in the global shift toward sustainable development and pollution prevention (p. 60). Hart and McClaren (1978) warned that the continued existence of many species including humans depends upon "our ability to make conscious changes in our cultural attitudes toward nature and our place in the biosphere" and that "conscious cultural change will almost surely depend upon the degree to which humans now perceive and regard the possible consequences of present behaviors if they continue into the future" (p. 497). Derkach (1990) suggested that students should develop social values and strong feelings of concern for the environment and the skills and desire to resolve those issues (p. 162). A similar point was made by Volk (1984) commenting on the Tbilisi Declaration (1978) which recommended that environmental education should develop knowledge, awareness, attitudes, concern, and sensitivity to the environment and its problems, and develop skills and motivation requisite to identify and resolve environmental problems (Volk, 1984; p. 26).

In order to deal with societal issues such as environmental-conservation, such issues are often infused into the regular science curriculum. Volk (1984) legitimates this by arguing that both environmental education and science education "are concerned with the development of individuals who are knowledgeable about science-related societal issues, competent to engage in the investigation, evaluation, and resolution of those issues, and motivated to do so" (p. 30). The American Association for the Advancement Science (AAAS) (1989) further legitimates the integration or incorporation of societal issues such as environmental-conservation in science education when it states that:
Science, energetically pursued, can provide humanity with knowledge of the biophysical environment and of social behavior that it needs to develop effective solutions to its global and local problems; without that knowledge, progress toward a safe world will be unnecessarily handicapped. . . . By emphasizing and explaining the dependency of living things on each other and on the physical environment, science fosters the kind of intelligent respect for nature that should inform decisions of recklessly destroying our life-support system. (p. 12)

These concerns are relevant to Zimbabwe where the current five year national development plan articulates that development of science and technology is Zimbabwe's long term and most important strategy for economic and social development (Government of Zimbabwe, 1991; p. 84); thus both the positive and negative social impacts of science and technology on society cannot be neglected. Further, the draft science and technology policy document indicates that investment in physical and technology innovation should be complimented by greater investment in human services development so that the natural environment can support higher population levels without degrading it in quality (National Research Council of Zimbabwe, 1991; p. 70). Issues pertaining to the environment, conservation, and sustainable development are also regular subjects for scientific papers published in both the Zimbabwe Science News and the Transactions of the Zimbabwe Scientific Association. Topical environmental-conservation issues in Zimbabwe include deforestation and woodland destruction, land degradation and soil erosion, pollution, urban crowding, extinction of wild-life flora and fauna species, overstocking, and many others.

As one of the strategies for making science education relevant to the local context, infusion of environmental and agricultural issues into curricula has emerged as one area of recent curriculum innovation (Ministry of Education and Culture, 1992). In primary school "Environmental and Agricultural Science" is mandatory for all students and at the Ordinary level the science subjects 5006 and 5007 have as their longest theme "Science in Agriculture" which deals extensively with environmental-conservation issues such as land management (Ministry of Education and Culture, 1992). Muchena (1990) also notes that environmental education components occur also in the school syllabi for three other subjects, agriculture, geography, and education for living. Including environmental and agricultural issues in science curricula appears to be valid curriculum innovation.
and practice (Steiner, 1973; Wiener, 1990; Volk, 1984). For example, following a survey of Canadian curricula, Wiener (1990) concludes that although environmental education has been described as interdisciplinary in nature, cutting across all of the curriculum, "it is strongly associated with and legitimized through the science curriculum and science education" (p. 187). Similarly, Steiner (1973) argues that, although societal issues are relevant to all education, they are 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).

Research questions

In the context of Zimbabwe, while the infusion of environmental and agricultural issues into the curriculum is appropriate, many science teachers typically do not have the requisite training and knowledge to implement new curricula as planned. Knowledge about teacher beliefs concerning the issues added to new curricula is also lacking and therefore their beliefs must be sought and used as a basis to plan and implement inservice training courses. Otherwise, a situation arises where teachers do not implement the curriculum in the same way it was intended to be implemented. The need for studies of teacher knowledge and belief is also apparent if one compares curriculum innovation at school level to that in teacher education at the teachers' colleges. The preceding overview demonstrated that curriculum innovation at the school level includes the infusion of environmental issues into science curricula. Little evidence of infusion of environmental issues in the science teacher education curricula exists. Indeed teachers continue to be trained in the traditional science disciplines despite the fact that at the school level they are required to integrate the sciences. Studies are needed therefore which find out whether or not teachers have socially acceptable opinions and attitudes concerning issues such as environmental-conservation which, besides being required in the curriculum, demonstrate the social implications of the application of science and technology. Teachers' awareness and attitudes influence the extent and strategies used to implement those issues and hence their role cannot be overemphasized. Teachers are key figures in influencing the attainment of scientific and technological literacy, which includes the
acquisition of environmental and conservation sensitive behaviors, in society. The National Research Council of Zimbabwe (1991) aptly noted that in-service and staff development training of science and technical subject teachers is necessary for them to respond effectively "to the scientific and technical emphasis urgently if Zimbabwe is to cope with the technological changes necessary for sustained economic growth and development" (p. 78). This study sought answers to two questions.

1. What is the level of awareness of BEd science teachers on a science and technology related societal issue, environmental-conservation?

2. How is their awareness of societal issues related to their orientation towards indigenous traditional culture, socio-cultural variables, instructional ideology, and to their understanding of the nature of science and scientific knowledge?

Studying, environmental-conservation awareness among teachers is significant because awareness precedes adoption of attitudes, principles, and codes of conduct that result in socially acceptable behaviors involving the preservation and conservation of the environment and natural resources. Such awareness among teachers is likely to precede the inclusion and effective treatment of such issues in science lessons and in science classes. Environmental-conservation awareness in this study was assumed to have four dimensions, i.e., cognizance of issues regarding the implications and outcomes of humanity's scientific and technological involvement with nature; awareness of the need for conservation and preservation of the environment and natural resources; awareness of the need to take personal responsibility for current societal problems; and cognizance of the ability, desirability, and limitations of science and technology to solve societal problems and to deal with environmental deficiencies (Steiner, 1973).

Knowledge of teachers environmental-conservation awareness is relevant also because an accurate conception of the nature of science includes an awareness of the interactions of science and technology with society (AAAS, 1989). As a tentative solution to the research questions, it was hypothesized that science teachers would have a low level of awareness of environmental-conservation issues. Their awareness of a science-technology related societal issue would be
reflected by an inadequate conception of the nature of science and by a preference for traditional instructional ideology. The awareness of societal issues was expected to have an inverse relationship with the socio-cultural variables as well as with their level of orientation towards indigenous cultural beliefs and values.

Sample

The study surveyed a sample comprised of 63 secondary science teachers who were reading for the Bachelor of Education (Science) degree at the University of Zimbabwe. Teachers in the program came from all nine educational administrative regions in Zimbabwe. They were certified and experienced in teaching secondary school science in form one through four (grades 8–11). The BEd program prepares teachers for major teaching and curriculum development responsibilities in Zimbabwe's education system; they are being prepared to teach science to all levels of the secondary sector including Form 6 (grade 13) and are also expected to be able to be effective in curriculum development, to teach in teachers colleges, and to service other divisions of the Ministries of Education (University of Zimbabwe, 1994). This makes it imperative for studies to establish whether or not they carry socially and professionally acceptable attitudes about societal issues such as environmental-conservation. Only nine females were in the program of which only eight responded to the questionnaire. Over 95% of all the science teachers were 35 years of age or younger; 41 were in the 26–30 age bracket and only 3 teachers were 31 years old or older. They were certified as teachers after Zimbabwe got its independence and thus their teaching experience was less than ten years for the majority, e.g., more than 95% had 9 or fewer years teaching experience. The majority (63.49%) had at least one pass grade in one of the sciences or mathematics at the advanced level. Their college and university academic performance records demonstrated that the majority of the teachers were of average academic ability. Forty five teachers representing 71.43% of the sample grew up in a religious environment in which both Christianity and traditional religion were practiced. Their current religious practice was either a combination of Christian and traditional religion (42.86%), Christianity (41.27%), or none
(14.28%). They came from a socio-cultural environment in which both parents had some basic level of literacy; only 8% of either fathers or mothers of the respondents were reported to be unable to read and write.

**Instrumentation**

The study utilized a researcher adapted scale to measure the BEd science teachers' environmental-conservation awareness (ECAS). Although other constructs such as understanding of the nature of science and scientific knowledge, instructional ideology, and orientation to indigenous culture were measured with the same sample, this article focuses mainly on presenting the results pertaining to awareness of a societal issue. Only the environmental-conservation awareness scale is discussed in detail.

In general, a number of instruments with the purpose of measuring environmental attitudes, awareness or knowledge varied widely in structure, scoring and/or interpretation. Hart and McLaren (1978) explained this by stating that "rapidly changing issues and the regional nature of some environmental concerns make standardization difficult" (p. 497). It was elected to select and adapt four subscales of the *Inventory of Societal Issues* (Steiner, 1973), i.e., Steiner's factors 2, 3, 5, and 6 out of the 7, which were relevant to environmental-conservation awareness issues which were relevant and topical in Zimbabwe. Some items were also adapted from Richmond's (1976) environmental attitude and knowledge inventory which also utilized some the Steiner items. Steiner's (1973) factors 1, 4, and 7 were not of interest to the present study because their referents dealt less directly with environmental or conservation awareness. The environmental-conservation factors on the ECAS are defined as they were originally defined by Steiner (1973; p. 419). In the following presentation of the factors, a new factor number has been assigned; the numbers in parentheses indicate the item numbers on the scale appended to this paper as Table A1 (Appendix).

Factor I. Optimistic belief in the ability and desirability of science and technology to solve societal problems and to deal with environmental deficiencies (2, 5, 9, 13, 16, 21, 23, 27, 30, & 33).
Factor II. Need to cooperate with nature rather than subjugate it. Specific referents include conservation and preservation of the environment and natural resources (3, 7, 10, 19, 22, 24, 28, & 35).

Factor III. Need to take personal responsibility for current societal problems. Specific referents include personal conveniences, luxuries, and enjoyments (1, 4, 8, 11, 12, 15, 17, 26, 31, & 34).

Factors IV. Disillusionment and pessimism regarding the implications and outcomes of man's scientific and technological involvement with nature (6, 14, 18, 20, 25, 29, & 32).

**Adaptation and interpretation of ECAS factors**

Adaptation of suitable items was done by re-writing and focusing items on Zimbabwe's environmental-conservation problems and issues. Items which were not at all applicable to the study context were simply deleted and replaced. For example, item 14 on Steiner's (1973) inventory read "our current cities are a lost cause; we need entirely new experimental cities" was deleted and a new item developed. Besides being ambiguous it would not apply to the context of Zimbabwe where there are relatively few cities. Items were also adapted by replacing terms like "man" with "person" or "people" in order to remove gender bias. The 35 suitable items were matched with a Likert type scale ranging from '1' strongly disagree to '5' strongly agree; the middle point '3' represented a neutral position neither agreeing nor disagreeing to an assertion. Structurally the items were maintained in the random order in which they occurred in the inventory of societal issues (Steiner, 1973).

The adapted ECAS comprised of four factors as described in a preceding section. Factor I measured pessimism in the unlimited and uncontrolled application of science and technology for economic gain with little, if any, regards to consequences and effects of their interaction with nature, the environment, and/or society (items 6, 14, 18, 20, 25, 29, & 32). In total there were 7 items for this factor as in the Steiner inventory. Three ISI items 49, 25, 22, and 9 were dropped and replaced with three more relevant items adapted from Richmond's (1976) inventory and one new one. This was done so that the items making up the scale were all relevant to the Zimbabwe context. For example, Steiner's item, "computers with their storage and retrieval capacities
represent a serious threat to the privacy of the individual" was replaced with a Richmond item "there is no need to worry about over-population because science and technology will solve the problem before it becomes too serious". A new item "controls should be placed on industry to protect the environment from pollution, even if it means products they make will cost more" was added.

Factor II was composed of five items adapted from Steiner's factor 3 and three items adapted from Richmond's (1976) scale (items 3, 7, 10, 19, 22, 24, 28, & 35). Item 7 and 24 were concerned with the need for pollution prevention; items 3, 22, and 28 addressed the need for conservation of natural resources; item 10, 19, and 35 were concerned respectively with preservation of soil productivity and erosion control and with protection and preservation of endangered species. Factor III indicated the "need to take personal responsibility for current societal problems" (Steiner, 1973; p. 419) (items 1, 4, 8, 11, 12, 15, 17, 26, 31, & 34). Together these items measured awareness of the need to sustain environmental quality through (i) taking personal responsibility, for example, by limiting the number of children per family, limiting the use of pesticides, and avoiding burning trash in open pits or incinerators, and reclaiming and re–using certain resources (items 4, 11, 12, & 17); and (ii) consideration of environmental quality over creation of jobs, employment or luxuries such as motor cars (items 1, 8, 15, 26, 31, & 34). The original factor comprised of 12 items but item 38 was dropped and items 19 and 34 on the Steiner scale were collapsed into one (item 12 on the ECAS) so that this factor now carries ten items. Steiner's item 38 read "considering the problems of pollution and crowding, we need to decrease the use of the automobile as a major means of transpiration" which was considered not applicable to the present context of Zimbabwe which is predominantly rural. A new ECAS item (item 17) "industries which make and use returnable containers and recyclable products need greater publicity and support" replaced Steiner's item 28 which read "the cost of automobile disposal should be paid by the auto–owner, not by society as a whole". Steiner's items 23 and 14 were replaced with items adapted from Richmond's (1976) inventory.
Factor IV measured "optimistic belief in the ability and desirability of science and technology to solve societal problems and to deal with environmental deficiencies" (Steiner, 1973; p. 419) (items 2, 5, 9, 13, 16, 21, 23, 27, 30, & 33). Steiner's (1973) item 20 was adapted to read "once advances in genetics give humans the ability to rid themselves and their crops and animals of hereditary defects, traits, etc., hunger and food shortages will be a thing of the past" (ECAS item 13). Steiner's item 33 was replaced with a new item "lack of advanced technology leads to environmental-conservation problems in Zimbabwe being over-exaggerated" (ECAS item 21). Item 51 was adapted to read "humanity's vast technological abilities should be used to develop non-chemical means of weed and pest control" (ECAS item 30). Item 46 was adapted to "with our ability to import, the oceans represent an almost limitless source of food and resources for the future" (ECAS item 27). In general, the ECAS has two significantly important elements. First, the individual items illustrate the cognitive-affective nature of environmental-conservation awareness. Second, the items were previously validated and were now adapted to the specific context of Zimbabwe.

Data analysis

Analysis was done using the StatView II computer program running on a Macintosh. Some ECAS items were stated in a way that an "agree" response represented a lack of awareness of the need for environmental-conservation and thus an "agree" response was considered negative. In preparing data for analysis, responses to these "negative" items were reversed so that a "strongly agree" response to these items was scored one point and a "strongly disagree" response was scored five points. Overall, a high score represented a higher level of environmental-conservation awareness and a lower score a lower environmental-conservation awareness. By reversing the scores for the negatively stated items all response were taken in the positive enabling consistency in score interpretation to be achieved. Scoring the ECAS and its 4 subscales was done by summing the scores on all items to obtain a composite score and by summing items making up a factor to get the subscore. These scores served as indices of environmental-conservation awareness. The total
average environmental-conservation awareness scores can range from a low of 35 indicating high
disagreement with scale items and low environmental awareness to a high of 105 showing high
environmental awareness. A one tailed t-test was conducted to test the null hypothesis that the
level of awareness would be no different from a "neutral" conception. This helped to evaluate the
direction of environmental-conservation awareness score as "positive and socially acceptable" or
"negative and non-acceptable". Item by item analysis was done and the results are summarized in
Table A1.

Validity and reliability

Validity of the environmental-conservation awareness scale was accepted on the basis of
the validation work of Steiner (1973), Hart and McClaren (1978), and Richmond (1976). Some
construct-related evidence of validity was established in the present study by determining the
inter-relationship between the environmental-conservation awareness scale and its four factors
with the results in Table 1. Scores on the four factors were positively and significantly correlated
to the mean total environment conservation awareness score (p < .05). This provided some evidence
that items belonging to the four factors measured the same construct "environmental-conservation
awareness". Only the scores Factor I "disillusionment and pessimism with science and technology"
in resolving environmental issues was significantly correlated to each of the other three factors
positively. The relationship between the three factors, "conservation of resources and preservation
of the environment", "taking personal responsibility" for the environment, and "optimism in the
ability of science and technology" to resolve environmental issues was modestly positive but non­
significant. The factors in the study were thus fairly independent, measuring different aspects of
the construct "environmental-conservation awareness". The odd–even split-half internal
consistency technique following the Spearman–Brown prophecy correction (Borg & Gall, 1989) was
moderately high (r = .66).
Table 1. Correlation matrix for environmental-conservation scale (ECAS) and its sub-scores

<table>
<thead>
<tr>
<th></th>
<th>ECAS</th>
<th>Pessimism</th>
<th>Conservation</th>
<th>Responsibility</th>
<th>Optimism</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECAS Score</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pessimism</td>
<td>.6513**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservation</td>
<td>.6556**</td>
<td>.3307**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility</td>
<td>.6263**</td>
<td>.2382*</td>
<td>.1521</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Optimism</td>
<td>.6555**</td>
<td>.2745*</td>
<td>.2091</td>
<td>.1679</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significant at the .05 level.

**Significant at the .01 level.

Note: The scale and subscales and their internal consistency reliability coefficients were as follows: ECAS Score = Total score (.66); Optimism = Factor I (.43); Conservation = Factor II (.56); Responsibility = Factor III (.37); and Pessimism = Factor IV (.43).

Results

The results of analyzing BEd science teachers' responses are presented in Table 2. Table 2 shows a summary of the science teachers' responses to the ECAS and its subscales. Table A1 (Appendix) is a supplementary table showing the item by item response profiles of environmental-conservation awareness of the science teachers. Table 2 shows that BEd science teachers had an environmental-conservation awareness score (mean = 117.17 SD = 10.72) which was significantly higher than a neutral index of 105 (t = 9.02 p = .0001); they had a positive and socially acceptable level of orientation to environmental-conservation issues. Further analysis established that the teachers had significantly positive environmental-conservation awareness scores for three of the four factors, 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" did not differ from the subscale neutral index of 30 (mean = 29.90 SD = 3.96 t = -0.20). This result corroborates the finding that the respondents were "pessimistic" about science and technology resolving
Table 2. Science teachers' environmental-conservation awareness (N = 63)

<table>
<thead>
<tr>
<th>Environmental-conservation Scale(^a)</th>
<th>Mean Score (S)(^b)</th>
<th>SD</th>
<th>d-Score (S - N)(^c)</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ECAS score (35)</td>
<td>117.17 [3.35]</td>
<td>10.72</td>
<td>12.17</td>
<td>9.02***</td>
</tr>
<tr>
<td>Optimism in science and technology (10)</td>
<td>29.90 [2.99]</td>
<td>3.96</td>
<td>-0.10</td>
<td>-0.20</td>
</tr>
<tr>
<td>Personal responsibility (10)</td>
<td>33.16 [3.32]</td>
<td>3.95</td>
<td>3.16</td>
<td>6.25***</td>
</tr>
<tr>
<td>Pessimism in science and technology (7)</td>
<td>26.32 [3.76]</td>
<td>2.92</td>
<td>5.32</td>
<td>14.10***</td>
</tr>
</tbody>
</table>

*** p ≤ .0001

\(^a\)Number in parentheses indicates number of items comprising the scale or subscale.

\(^b\)Score obtained by summing scores to the individual items comprising the scale or subscale. The numbers in parentheses are the scores equivalents on the 5-point scale.

\(^c\)The d-Score is the deviation score obtained by subtracting neutral score (N) for that scale or subscale from its scale or subscale score (S). The neutral score is obtained by multiplying the number of items in that scale or subscale by a value of 3.

Environmental issues; respondents were consistent in their ratings since a high pessimism score was complemented by a lower optimism score. An item by item analysis resulted in the following profile of environmental-conservation awareness (see Table A1).

**Factor I: optimism in science and technology**

Their overall response to Factor I was "uncertain". BEd science teachers demonstrated neither optimism nor lack of optimism in the ability and desirability of science and technology to solve societal problems and to deal with environmental deficiencies. However, they were relatively optimistic on four of the items. For example, 82.25% and 73.01% agreed, respectively, that when nature is deficient in doing what it should for human welfare, science and technology must make up that deficiency, and that technology's positive contribution to our lives far outweighs the negative. For five items 2, 5, 9, 13, and 21 their response was "uncertain". A slight majority, 53.97% and about 50.00%, respectively, agreed that science and technology should attempt to
control the weather and there is no social problem so complex that it cannot be solved once science
and technology are committed to its solution. This perception may reflect unrealistic and even
uncautious expectations for science and technology. They were almost evenly split between those
agreeing and disagreeing on whether or not automation holds the promise of the future (33.33%
agree and 33.33% disagreeing), whether or not advances in genetics give humans the ability to rid
themselves and their crops and animals of hereditary defects and eradication of hunger (41.94%
agree vs. 40.33% disagreeing), and whether or not lack of advanced technology led to the
exaggeration of environmental-conservation problems in Zimbabwe (44.44% agree vs. 47.62%
disagreeing). BEd science teachers neither had nor lacked optimism in the belief ability concerning
the desirability of science and technology to solve societal problems and to deal with
environmental deficiencies.

Factor II: conservation of resources and preservation of the environment

Responses to Factor II showed a significantly positive (p < .0001) awareness of the need to
conserve resources and to preserve the environment (mean = 28.97 SD = 3.79 t = 10.32). Respondents
had a clearly positive awareness on 6 items and were close to "uncertain" response on two items.
Overall, their response profiles showed an awareness of the need for preventing pollution. For
example, 72.13% disagreed with statement 24 "there is no point in attempting to take nature back to
its pristine/original un-polluted condition". Close to 90% agreed that wildlife refuges and undis­
turbed natural areas such as the Hwange Game Park are necessary to protect endangered species and
to perpetuate gene pools. More than 82% disagreed that "conservationists" pleas for total
protection of an area rich in natural resources such as wildlife are unrealistic. This indicated an
awareness of the need to conserve or protect wildlife. They also demonstrated a positive awareness
of the need for preserving soil productivity and for erosion control. For example, 88.90% disagreed
that agricultural practices that maintain or improve soil productivity are essential for commercial
farmers but not for poorer subsistence communal farmers. Just over 71% thought that government
should give incentives to those who remove highly erodible land from crop production. They were,
however, split in their response (48.39% agreeing and 41.93% disagreeing) to the item which stated that land should be utilized in a manner that the most people benefit from its ultimate use, even if it means giving up already preserved areas.

**Factor III: taking personal responsibility**

Overall, the BEd science teachers had a significantly positive awareness of the need to sustain environmental quality and to conserve resources by taking personal responsibility as measured on Factor III (mean = 33.16 SD = 3.95 t 6.25 p < .001). Respondents were clearly positive in their response to four items, 1, 8, 17, and 31, neutral in their response to 5, and negative only to 1 item. The top rated items pertained to recycling and consideration of environmental quality over the creation of jobs or use of luxuries such as the motor car. Nearly all (96.77%) agreed that industries which make and use returnable containers and recyclable products need greater publicity and support. Almost 81% disagreed to an item which asserted that environmental quality considerations should be secondary when economic considerations are involved. Only 54.84% agreed that the most important thing to consider in bringing new industry into this country is the number of new jobs it will create. A clear majority were aware that "management of natural resources to meet needs of future generations demands long-range planning" (93.65% agreed). However, a clear majority disagreed that we must eliminate use of pesticides to ensure health and safety of humans, domestic animals, and wildlife if this were likely to result in poorer crops. Respondents were "uncertain" on five items, 4, 12, 15, 26, and 34, which were rated close to the neutral index of 3.00. Examples of the items in which they were "uncertain" with the percent agreeing in parentheses were: item 26 "to reduce petroleum consumption, only small efficient cars should be manufactured" (38.72%), and item 34 "until technology can make substantial reduction in auto pollutants, families should be encouraged to have only one motor car" (40.32%). The results of item analysis question the degree to which the teachers in this study might live according to their ratings, i.e., their response profiles create doubts about the extent to which they are likely to support or sacrifice certain luxuries like use of a large car for car-pooling.
Factor IV: pessimism in science and technology

More than 62% felt that it is unfortunate that there are fewer and fewer areas in the country where people have never explored and nearly 84% believed that controls should be placed on industry to protect the environment from pollution, even if it means products they make will cost more. Over 52% felt that humans should not tamper with the grandeur and magnificence of nature. However, almost 79% disagreed that science can never solve the environmental problems which are really important to people. Over 62% did not think that the demand for energy in the country is critical enough to justify relaxing environmental restrictions which may hinder energy production and 93% did not believe that the problem of over-population can be resolved by science and technology. Overall, the BEd science teachers showed some pessimism and disillusionment regarding the implications and outcomes of scientific and technological involvement with the environment and felt that some controls on science and technology were necessary (mean = 26.32 SD = 2.92 t = 14.10 p < .001).

Relationship between environmental-conservation awareness and other constructs

In designing the broader study it was speculated that understanding teachers' awareness of societal issues is necessary in order to fully describe their conceptions of the nature of science. Because 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 world-view. An effort was therefore made to measure the level of commitment of teachers to indigenous traditional values and beliefs; it was expected that the teachers would have some inclination towards traditional culture and world-view. As traditional culture tends to be authoritarian, such a commitment would be expected to influence teachers so that they would have conception of the nature of science including its relationship to society and instructional ideology which was authoritarian, traditional, and non-inquiry-oriented. Table 3 summarizes scores obtained on each measure. It also presents the results of testing the significance of difference from
Table 3. BEd science teachers' scores on measures of understanding of the nature of science, instructional ideology preference, and orientation to indigenous culture (N = 63)

<table>
<thead>
<tr>
<th>Construct and Measures(^a)</th>
<th>Mean total score(^b)</th>
<th>SD</th>
<th>d-score</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of science (NOSS) [29]</td>
<td>74.37 [2.56]</td>
<td>7.18</td>
<td>-12.63</td>
<td>-13.98**</td>
</tr>
<tr>
<td>Nature of scientific knowledge (NSKS) [48]</td>
<td>168.81 [3.52]</td>
<td>12.86</td>
<td>24.81</td>
<td>15.18***</td>
</tr>
<tr>
<td>Inquiry instructional ideology preference (STIPS) [10]</td>
<td>38.35 [3.84]</td>
<td>4.20</td>
<td>8.35</td>
<td>15.68***</td>
</tr>
<tr>
<td>Environmental–conservation awareness (ECAS)</td>
<td>117.17 [3.35]</td>
<td>10.72</td>
<td>12.17</td>
<td>9.02***</td>
</tr>
</tbody>
</table>

\(^a\) Number in the parentheses is the number of items in the scale or subscale.

\(^b\) The numbers in parentheses are the score equivalents on the 5-point scale.

** p < .01

*** p < .001

Note: 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).
the appropriate neutral index for that scale. A brief description of each measure as well as the internal consistency reliability of the scales are given also in Table 3.

The relationships among BEd science teachers nature of science profiles, environmental-conservation awareness, instructional ideology, and orientation towards indigenous culture are summarized in Table 4. The individual correlations 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. Following the deletion of missing cases, it was established that a correlation coefficient of .23 or higher was required for significance at the .05 level and the critical value of the coefficient was .32 at the .01 level (df = 58 - 2 = 56; one-tailed t-test). Based on the correlation matrix (Table 4) the following observations can be made about relationships among the five constructs in the study.

Table 4. Correlation among BEd science teachers' scores on the nature of science, instructional ideology, environmental-conservation, and cultural orientationa

<table>
<thead>
<tr>
<th>VARIABLESb</th>
<th>NSKS</th>
<th>ECAS</th>
<th>SPT</th>
<th>SPI</th>
<th>NOSS</th>
<th>OICS</th>
<th>TTC</th>
<th>BED</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSKS</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECAS</td>
<td>.20</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPT</td>
<td>.18</td>
<td>.01</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td>-.12</td>
<td>.30*</td>
<td>-.22</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOSS</td>
<td>-.00</td>
<td>.27*</td>
<td>-.44**</td>
<td>.05</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OICS</td>
<td>-.05</td>
<td>-.22</td>
<td>.40*</td>
<td>-.03</td>
<td>-.07</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC</td>
<td>-.06</td>
<td>.04</td>
<td>.06</td>
<td>.02</td>
<td>.08</td>
<td>.15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>BED</td>
<td>-.03</td>
<td>-.18</td>
<td>.23*</td>
<td>-.07</td>
<td>-.23*</td>
<td>.08</td>
<td>.27*</td>
<td>1</td>
</tr>
</tbody>
</table>

*Significant at p ≤ .05.
**Significant at p ≤ .01.

a Sample size n = 58 because 5 missing cases deleted.
b Abbreviations for constructs in the study were as follows:

NSKS = nature of scientific knowledge score; ECAS = environmental conservation awareness score; SPT = preference for inquiry instructional ideology score; SPI = preference for traditional instructional ideology score; NOSS = nature of science score; OICS = orientation to indigenous culture score; TTC = pre-service teacher training score; and BED = BEd Part I score.
Awareness of environmental-conservation is 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 (-.18). No relationship was found between environmental-conservation scores and either the teacher training performance score or the preference for traditional instructional ideology. A significant positive relationship was observed between the science teachers' orientation to indigenous culture scores and preference for traditional non-inquiry instruction scores ($r = .40$). An orientation toward indigenous culture and a preference for traditional methods of instruction reflects, relatively, a degree of authoritarianism. Interestingly, for this sample, there is zero correlation between nature of scientific knowledge scores and the nature of science scores. Another interesting finding in the data in Table 4 is the lack of significant relationship between pre-service teacher training scores and between BEd Part I scores and constructs of the study. In fact, BEd Part I score was significantly correlated to the preference for traditional ideology score ($r = .23$) and negatively to the nature of science score ($r = -.23$); it also had a modest negative relationship with nature of scientific knowledge, environmental-conservation awareness, and inquiry instructional ideology scores. Academic and professional qualification, age teaching experience, and gender as well as the socio-cultural environment variables (REP = religious practice; ETH = ethnic group; GRO = where grew up; REN = religious environment grown in; MOL = mother's literacy level; FAL = father's literacy level; MOE = mother's educational level; and FAE = father's educational level) had no substantive relationship to awareness of environmental-conservation issues measured by the ECAS. The personal and demographic variables are not shown in the matrix to conserve space.
Discussion

BEd science teachers had a socially acceptable level of environmental-conservation awareness; they demonstrated an awareness of the need to preserve and conserve the environment and natural resources and the need to take personal responsibility to accomplish that. Further studies are necessary to find out if the teachers actually live by their ratings and whether they incorporate such issues in their teaching. Their awareness profiles reflected that they had pessimism and even some disillusionment, and a relatively low optimism in the ability and desirability of science and technology to resolve environmental-conservation issues. This finding can be interpreted to say that teachers did not see the solution of environmental problems to lie in the application of technology but rather in humanity living by and taking socially responsible actions. A goal of school science education should therefore be to help students acquire environmentally friendly attitudes and actions (Steiner, 1973; Derkach, 1990; Volk, 1984). Such goals are already reflected in school science education curricula in Zimbabwe and should also be infused into the science teacher education curricula.

The significance of the perceptions found with this sample regarding environmental issues should also be interpreted with reference to relationships of their environmental-conservation awareness scores to scores on other measures administered to the sample. For example there was a positive relationship among the teachers' awareness of societal issues such as environmental-conservation, preference for inquiry instructional ideology, and their nature of science or the nature of scientific knowledge scores. Teachers with high nature of science scores also had greater awareness of environmental-conservation which in this study represented a test of the awareness of interaction of the science, technology, and society or societal issues. A positive perception to these variables represents a proper perspective on goals to be accomplished in science education.

Similarly the negative relationship between orientation toward indigenous culture scores and either preference for inquiry, nature of science scores or nature of scientific knowledge scores and between preference for non-inquiry and either NOSS or preference for inquiry while modest with
This sample was predicted. Although it has been reported that some environment friendly behaviors are facilitated in indigenous culture (Muchena, 1990), knowledge about and beliefs concerning traditional culture in this study appear to have little relationship to the teachers' awareness of the nature of science or science-related societal issues. However, scores indicating orientation toward indigenous culture were positively related to a preference for traditional non-inquiry instruction. Both an orientation toward indigenous culture and a preference for traditional methods of instruction are theorized to reflect, relatively, some degree of authoritarianism. This authoritarian tendency is expected to be greater with older teachers which would have serious implications 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. It should be noted also that an orientation to indigenous culture was modestly but negatively correlated to nature of science, environmental-conservation awareness, inquiry instructional ideology, and nature of scientific knowledge scores.

BEd science teachers demonstrated a satisfactory level of environmental-conservation awareness. Although tentatively it can be concluded that science teachers had awareness of some science-technology-society interactions, these teachers did not adequately view the nature of science in terms of the model responses proposed by Kimball (1967). On the NOSS (Kimball, 1967), the 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. In Zimbabwe, national policy documents and curricula interchange acquisition of scientific world-view with modernism and with social and economic development. This national expectation for science and technology to improve the material and technological condition of the nation appears to be manifest in the BEd science
teachers' perceptions of the nature of science. It is necessary to take heed of the potential consequences this might have on the perceptions of teachers and hence in education. 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). Cobern (1989) notes that acceptance of science in development can raise unrealistic expectations for science since there is more to technological development than just a scientific base. Science could be rejected in the future when the public finds that science fails to deliver satisfactory solutions to emergent societal issues. Results obtained with this sample of teachers suggests that although they considered science and technology as useful to society, they expressed a relatively strong pessimistic view about the ability of science and technology to resolve environmental or conservation problems and issues. This disillusionment could have deleterious consequences in the rest of society who may not be as scientifically informed as teachers in this study.

In results described elsewhere (Shumba, 1994), the BEd sample in this study did not see scientific knowledge as parsimonious and they perceived of a single scientific method with a determinate number of procedural steps; they did not possess a definitive understanding of the use of models and/or the role classification schemes in science. They were "uncertain" whether scientific knowledge was amoral or not, i.e., could be judged good or bad. They accepted the view of science as an organized body of knowledge and believed in a single scientific method which had a determinate number of steps. This sample of 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. Although it is not clear how the inadequate conceptions concerning the nature of science are connected to their lack of optimism in science and technology in resolving societal issues, the fact that this kind of perception exists should cause science educators to raise eyebrows. First, inadequate perceptions are likely to have consequences
which must be investigated to find out their implications for the attainment of scientific literacy.

Second, science can be perceived as a technology. Odhiambo (1968) once noted this danger of African science students appreciating technological products or technological aspects of science while remaining perplexed by the "inner spirit of science". Science can easily be treated as a technology or as a set of procedures and rules which then limits "the understanding to of science to the facility with which one can regurgitate facts" (Odhiambo, 1968; p. 39).

In this study variables such as subject specialization, gender, age group, academic qualifications, teacher training program, professional qualifications, teaching experience, pre-service training college, vernacular language spoken, region of origin, ethnic group, religious practice, mother and/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 relationship to the teachers' perception of environmental-conservation or to other constructs measured. These variables may lack importance for a sample comprised of teachers whose exposure to science is at an advanced level but could be important for younger samples of students. Further studies should find out how to deal with factors such as the indigenous world-view and in particular how certain environmental issues are perceived.

Conclusion

In conclusion, it must be observed that there is no relationship between performance of teachers on the preservice teacher education program and at the end of Part I of the BEd program and either environmental-conservation awareness or other nature of science-related constructs studied. However, the personal, socio-cultural, and professional variables theorized to be related to or which account for differences in teacher ratings were not found to do so. It is therefore possible that depressed scores on the nature of science and scientific knowledge scales and the lack of optimism in science and technology could be accounted for by the nature of the science teacher education curricula and programs; they over-emphasize the structure and content of the academic disciplines and fail to incorporate substantive considerations of the philosophical and sociological
aspects of the nature of science. The continued lack of deliberate treatment of issues such as environmental-conservation in science teacher education will continue to have a detrimental effect on the potential to deal with environmental and conservation issues and problems or to acquire scientific and technological literacy.

Certainly further research is necessary to better understand teacher beliefs concerning a wider range of societal issues, the nature of science, and indigenous culture and how these beliefs manifest themselves in Zimbabwe's classrooms. Further, the question of how science teacher education can best prepare teachers for dealing meaningfully with issues in the Zimbabwean context begs for further research. This study demonstrated that science teachers already had environmentally friendly attitudes but the question remains to find out if they implement their beliefs in the community and in school.

References


## Table A1. Item analysis of responses to the environmental-conservation awareness scale (N = 63)

<table>
<thead>
<tr>
<th>ECAS Subscales and Items</th>
<th>$^a$Disagree</th>
<th>$^b$Uncertain</th>
<th>Agree</th>
<th>Mean</th>
<th>SD</th>
<th>Rank$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimism in science and technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Science and technology should attempt to control the weather.</td>
<td>36.51</td>
<td>9.52</td>
<td>53.97</td>
<td>3.13</td>
<td>1.20</td>
<td>32 (8)</td>
</tr>
<tr>
<td>5. There is no social problem so complex that it cannot be solved once science and technology are committed to its solution.</td>
<td>35.49</td>
<td>14.52</td>
<td>49.99</td>
<td>3.08</td>
<td>1.12</td>
<td>31 (7)</td>
</tr>
<tr>
<td>9. Automation holds the promise of the future with new abundance for all, new leisure and freedoms.</td>
<td>33.33</td>
<td>33.33</td>
<td>33.33</td>
<td>3.00</td>
<td>0.93</td>
<td>28.5 (5.5)</td>
</tr>
<tr>
<td>13. Once advances in genetics give humans the ability to rid themselves and their crops and animals of hereditary defects, traits, etc., hunger and food shortages will be things of the past.</td>
<td>40.32</td>
<td>17.74</td>
<td>41.94</td>
<td>3.00</td>
<td>1.04</td>
<td>28.5 (5.5)</td>
</tr>
<tr>
<td>16. When nature is deficient in doing what it should for human welfare, science and technology must make up that deficiency.</td>
<td>11.29</td>
<td>6.45</td>
<td>82.25</td>
<td>3.79</td>
<td>0.75</td>
<td>34 (10)</td>
</tr>
<tr>
<td>21. Lack of advanced technology leads to exaggeration of environmental-conservation problems in Zimbabwe.</td>
<td>48.39</td>
<td>8.06</td>
<td>43.55</td>
<td>2.97</td>
<td>1.11</td>
<td>27 (4)</td>
</tr>
<tr>
<td>23. Technology’s positive contribution to our lives far outweighs the negative.</td>
<td>14.52</td>
<td>12.90</td>
<td>72.58</td>
<td>3.76</td>
<td>0.91</td>
<td>33 (9)</td>
</tr>
<tr>
<td>27. With our ability to import, the oceans represent an almost limitless source of food and resources for the future.</td>
<td>44.27</td>
<td>19.67</td>
<td>36.06</td>
<td>2.81</td>
<td>1.08</td>
<td>20 (3)</td>
</tr>
<tr>
<td>30. Humanity’s vast technological abilities should be used to develop non-chemical means of weed and pest control.</td>
<td>6.56</td>
<td>3.28</td>
<td>90.16</td>
<td>4.05</td>
<td>0.78</td>
<td>7 (1)</td>
</tr>
<tr>
<td>33. Science and technology will probably develop new foods that can be mass produced to feed the world’s hungry.</td>
<td>31.66</td>
<td>20.00</td>
<td>48.33</td>
<td>3.20</td>
<td>1.15</td>
<td>19 (2)</td>
</tr>
<tr>
<td><strong>Environmental preservation and resource conservation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Conservationists’ pleas for total protection of an area rich in natural resources such as wildlife are unrealistic.</td>
<td>82.54</td>
<td>1.59</td>
<td>15.87</td>
<td>2.19</td>
<td>0.88</td>
<td>10 (3)</td>
</tr>
<tr>
<td>7. Pollution of the environment is due to an unaware and unconcerned public citizens.</td>
<td>41.27</td>
<td>6.35</td>
<td>52.38</td>
<td>3.16</td>
<td>1.17</td>
<td>21 (7)</td>
</tr>
<tr>
<td>10. Agricultural practices that maintain or improve soil productivity are essential for commercial farmers but not for poorer subsistence communal farmers.</td>
<td>88.89</td>
<td>3.17</td>
<td>7.94</td>
<td>1.83</td>
<td>0.94</td>
<td>4 (1)</td>
</tr>
<tr>
<td>19. Government must give incentives to those who remove highly erodible land from crop production.</td>
<td>12.90</td>
<td>16.13</td>
<td>70.97</td>
<td>3.70</td>
<td>0.83</td>
<td>12 (4)</td>
</tr>
<tr>
<td>22. Wildlife refuges and undisturbed natural areas such as Hwange Game Park are necessary to protect endangered species and to perpetuate gene pools.</td>
<td>4.84</td>
<td>1.61</td>
<td>93.55</td>
<td>4.08</td>
<td>0.99</td>
<td>6 (2)</td>
</tr>
<tr>
<td>24. There is no point in attempting to take nature back to its pristine/original un-polluted condition.</td>
<td>72.13</td>
<td>8.20</td>
<td>19.67</td>
<td>2.31</td>
<td>1.11</td>
<td>13 (5)</td>
</tr>
<tr>
<td>28. Land should be utilized in such a manner that the most people benefit from its ultimate use, even if it means giving up already preserved areas.</td>
<td>47.54</td>
<td>19.67</td>
<td>42.62</td>
<td>2.95</td>
<td>1.12</td>
<td>25.5 (8)</td>
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$^a$Percentage disagreeing or agreeing to statements as presented.

$^b$Rank in parentheses is that for the subscale.
Table A1. (Continued)

35. Extinction of some species of wildlife is a necessary result of people's involvement with nature.

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<tbody>
<tr>
<td>62.29</td>
<td>4.92</td>
<td>32.79</td>
<td>2.68</td>
<td>1.26</td>
<td>16 (6)</td>
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Taking Personal Responsibility

1. Environmental quality considerations should be secondary when economic considerations are involved.

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<tbody>
<tr>
<td>80.95</td>
<td>6.35</td>
<td>12.70</td>
<td>2.00</td>
<td>0.95</td>
<td>8 (3)</td>
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4. Population growth is a critical problem facing humankind, it is irresponsible to have more than two children.

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<tbody>
<tr>
<td>42.86</td>
<td>7.94</td>
<td>49.20</td>
<td>3.06</td>
<td>1.15</td>
<td>24 (7)</td>
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8. Management of natural resources to meet needs of future generations demands long-range planning.

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<tbody>
<tr>
<td>4.76</td>
<td>1.59</td>
<td>93.65</td>
<td>4.11</td>
<td>0.72</td>
<td>5 (2)</td>
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11. We must eliminate use of pesticides to ensure health and safety of humans, domestic animals and wildlife, even if this will result in poorer crops.

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<tbody>
<tr>
<td>84.13</td>
<td>4.76</td>
<td>11.11</td>
<td>2.19</td>
<td>0.86</td>
<td>35 (10)</td>
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12. Private citizens should not be allowed to burn rubbish and trash in outdoor incinerators or rubbish pits because of their contributions to air pollution.

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<tbody>
<tr>
<td>44.44</td>
<td>7.94</td>
<td>47.62</td>
<td>3.11</td>
<td>1.12</td>
<td>23 (6)</td>
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15. The most important thing to consider in bringing new industry into this country is the number of new jobs it will create.

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<tr>
<td>54.83</td>
<td>3.23</td>
<td>41.94</td>
<td>2.87</td>
<td>1.21</td>
<td>22 (5)</td>
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17. Industries which make and use returnable containers and recyclable products need greater publicity and support.

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<tr>
<td>3.23</td>
<td>0.00</td>
<td>96.77</td>
<td>4.29</td>
<td>0.71</td>
<td>3 (1)</td>
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26. To reduce petroleum consumption, only small efficient cars should be manufactured.

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<tr>
<td>42.62</td>
<td>21.31</td>
<td>36.07</td>
<td>3.05</td>
<td>1.08</td>
<td>25.5 (8)</td>
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31. To reduce the number of cars on the road, commuters should not be allowed to drive to work alone unless it is a real necessity.

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<tr>
<td>36.07</td>
<td>11.48</td>
<td>52.45</td>
<td>3.27</td>
<td>1.09</td>
<td>17.5 (4)</td>
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34. Until technology can make substantial reduction in auto pollutants, families should be encouraged to have only one motor car.

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<tr>
<td>44.26</td>
<td>14.75</td>
<td>40.99</td>
<td>2.98</td>
<td>1.12</td>
<td>30 (9)</td>
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Pessimism in science and technology

6. Farmers should be allowed to use any pesticide they wish to control the pests that eat their crops.

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<tr>
<td>93.66</td>
<td>3.17</td>
<td>3.17</td>
<td>1.63</td>
<td>0.70</td>
<td>1 (1)</td>
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14. The demand for energy in this country is critical enough to justify relaxing some of the environmental restrictions which hinder energy production.

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<tr>
<td>61.29</td>
<td>3.23</td>
<td>35.48</td>
<td>2.64</td>
<td>1.07</td>
<td>15 (6)</td>
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18. There is no need to worry about over-population because science and technology will solve the problem before it becomes too serious.

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<tr>
<td>93.54</td>
<td>3.23</td>
<td>3.23</td>
<td>1.68</td>
<td>0.83</td>
<td>2 (2)</td>
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20. Humans should not tamper with the grandeur and magnificence of nature.

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<td>24.59</td>
<td>22.95</td>
<td>52.46</td>
<td>3.27</td>
<td>0.98</td>
<td>17.5 (7)</td>
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25. Science can never solve the environmental problems which are really important to people.

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<tr>
<td>78.69</td>
<td>3.28</td>
<td>18.03</td>
<td>2.21</td>
<td>0.94</td>
<td>11 (4)</td>
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29. Controls should be placed in industry to protect the environment from pollution, even if it means products they make will cost more.

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<tr>
<td>14.76</td>
<td>1.64</td>
<td>83.60</td>
<td>3.90</td>
<td>1.00</td>
<td>9 (3)</td>
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32. It is unfortunate that there are fewer and fewer areas in this country where people have never explored.

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<td>24.59</td>
<td>13.11</td>
<td>62.30</td>
<td>3.39</td>
<td>1.06</td>
<td>14 (5)</td>
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CHAPTER VIII. SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Introduction

This descriptive correlational study explored relationships among indigenous Zimbabwean science teachers' perceptions on traditional culture, instructional ideology, the nature of science, and on a societal issue, environmental-conservation. It also sought to describe the teachers' academic, professional, family, and socio-cultural backgrounds and how these variables were related to perceptions on these constructs. The questionnaire survey (Borg & Gall, 1989; Ary, et al., 1990) and a random sample focus group interview (Krueger, 1988) were used to collect data. Chapters I, II, and III presented, respectively, the research problem, the review and analysis of the literature, and the summary of the methodology used to collect and analyze data. Details concerning instrumentation, data analysis, and results were presented in Chapters IV, V, VI, and VII. This chapter contains a summary and discussion of the findings as they apply to the larger problem presented in Chapter I. Conclusions and recommendations for further research are presented.

Interpretation of results and conclusions

The research questions and hypotheses were stated in Chapter I and Chapter III, respectively. This section summarizes the results and draws conclusions reached in testing null hypotheses stated in Chapter III. The sample consisted of 63 certified science teachers enrolled in Part II of the Bachelor of Education (BEd) degree program at the University of Zimbabwe. Although they came from all 9 educational administrative regions, only 9 teachers on the program were female. Their distribution according to specialization was biology (28.57%), physics (41.27%), and chemistry (30.16%). Over 95% of the teachers were 35 years of age or younger or had 9 or fewer years in teaching experience. Their academic performance during preservice teacher preparation and at the end of Part I of the BEd program was average. More than 71% grew up in a religious environment in which both Christianity and traditional religions were practiced.
Currently their religious practices were both Christianity and traditional (42.86%), Christianity (41.27%), or non-religious (14.28%). The majority of teachers grew up in families where both parents had at least primary level education. Overall, the teachers in the study were relatively homogenous in their demographics. This relative homogeneity may partially account for the observed lack of meaningful or significant relationship between nearly all of the academic, professional, and socio-cultural environment variables and constructs of the study (Chapter VI).

An assumption in the study was that a relationship exists between the socio-cultural context teachers grew up in and their perception of the nature of science, science-related societal issues, and science instructional ideology. In particular it was assumed that the fundamental assumptions of traditional culture were different from the scientific world-view to be acquired in science education. Therefore, one purpose of the study was to highlight the nature of socio-cultural context by describing the nature of traditional culture in Zimbabwe. The review of the literature and interview with three experts (Chapter II) and personal experience led to the following observations about indigenous culture in Zimbabwe.

Many Zimbabweans have adopted western material values, Chirungu, but they still 'cling closely' to their moral and spiritual past, Chivanhu. Chapter II, IV, and V presented some evidence that the way phenomena were experienced and interpreted or explained in traditional culture was based on different philosophical assumptions relative to science. Traditional culture was shown to have an authoritarian structure which regulates social and spiritual relationships, problem solving, and other 'normal' behaviors. In traditional culture, experiences and phenomena are perceived and interpreted from a deeply personalized and subjective viewpoint. Group consensus and the subordination of individual opinion to group thinking and action is valued more than individual decision making and action. This is enforced through an extended family structure and a community structure in which linear and hierarchical relationships are valued. Sex role type education is based in the belief that social roles should be delineated by gender. Some claim that gender differentiation is practiced not "to prejudice the child against the other sex, but to let
it grow naturally into its predestined role" (Aschwanden, 1982; p. 44). In addition, for each person the functions in the family and in the kinship group are defined also according to age. At particular ages, the pre-specified functions are performed following a fixed code of manners and adhering strictly to the "correct" procedures laid down by tradition. There is always a strictly enforced "correct" traditional method or procedure for virtually all activities and problem situations (Gelfand, 1965).

Belief in ancestors and other spirits capable of disrupting normal existence and creating social tension leads to interpretation of experiences which is deeply personalized, subjective, and connected to quality of the people–people and people–spirits relationships (Bourdillon, 1987; Gelfand, 1973). These relationships are featured tremendously in people's perception of causality and causal relationships. As Gelfand notes, a subjective view of interpreting experiences makes the sustenance of social relationships vital "with an almost neglect of the material aspects of life" (Gelfand, 1973; p. 198). A subjective interpretation of experience and phenomena contributes to a perception that everything has an underlying cause and an attitude that virtually everything can be explained. This certainty about causes is supported by an attendant readiness to provide cosmological and mystical explanations. Belief in cosmological causes or mystical explanations is supported and validated via top-down problem solving processes such as divination, dreaming, and revelation. Divination, for example, is thought to provide a means to acquire understanding of the nature of the problem and a sure means to provide a psychologically satisfying solution. In this case, a spirit medium or diviner is consulted to make contact, receive and communicate messages to and from the spirits. This process is thought to enable people to be given knowledge of things that would otherwise be difficult or impossible to know (Mbiti, 1990; p. 167). According to Kirby (1986) divination "offers the means of knowing what cannot be experienced empirically through the senses or deduced by logic" and therefore increases certainty and predictability about occurrence of life experiences (p. 105). MacGaffey (1986) speculated that diviners or healers may be regarded
something like scientists since their role includes attempts to explain some part of experienced reality.

In light of such assumptions about experiences and phenomena, answers to two questions concerning the interaction of indigenous culture with science education were addressed in Chapter IV and V. The first question asked about the extent to which science teachers had an orientation toward African indigenous culture. The question was addressed with data gathered by a researcher developed orientation to indigenous scale (OICS). BEd science teachers had a low orientation toward indigenous culture (mean score = 102.49 SD = 13.66 t = -13.65 p ≤ .0001). The second question sought science teachers perception on indigenous culture and its influence on indigenous students' perception and acquisition of scientific knowledge and processes. Two approaches, open responses to a written question and a structured random sample focus group interview as described by Krueger (1988), were used to collect data to answer the second question. Content analysis done on the open-ended response text was substantially reliable (r = .93); practically all science teachers' (94.83%) 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 the 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. Chapter IV gave open ended data which exemplified instances of "African science". Fewer than 20% of the written open responses exemplified practices in indigenous culture which could be useful to science education. Negative evaluations 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 solv-
ing, conservative orientation to social change, and views concerning mysterious and sacred perception of relationship of humans with nature and supernatural forces.

A major aspect of the study was to find out the perception of science teachers on the nature of science and scientific knowledge and to determine how their perceptions compared to models of the nature of science (Kimball, 1967) and scientific knowledge (Rubba & Andersen, 1978) and to perceptions of teachers in other countries. $H_0^2$ stated that science teachers will have neither adequate nor inadequate understanding of the nature of science when measured, respectively on the Kimball (1967) and on Rubba and Andersen (1978) scales. 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. $H_0^2$ is rejected with respect to the Kimball (1967) model. 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 $< .0001$). $H_0^2$ is also rejected with respect to the Rubba-Andersen (1978) model. It should be noted that this attempt to internally replicate the study was based partly on the hypothesis that a positive relationship between Kimball's NOSS and Rubba-Andersen's NSKS exists. The NOSS score was not related to the NSKS score ($r = .02$) and thus the hypothesis is not supported. This may suggest that the two scales are perceived by this sample to measure different aspects of the construct 'nature of science'. The NOSS statements tended to reflect the characteristics of 'scientific activity' as opposed to the characteristics of scientific knowledge measured on the NSKS. BEd science teachers demonstrated an adequate conception of the nature of scientific knowledge but possessed an inadequate view of the nature of scientific activity. Although the reasons why are not clear, this inconsistency in ratings when respondents are presented different models of the nature of science has been noted in the literature (Meichtry, 1993).

$H_0^3$ stated that BEd science teachers' scores on the nature of science and on the nature of scientific knowledge will be equal to scores of American and Nigerian science teachers. 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; Cobem, 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. Null hypothesis $H_03$ is rejected with respect to the American sample and retained with respect to the Nigerian sample. $H_03$ was also tested with the nature of scientific knowledge (NSKS) profiles of Zimbabwean teachers and American high school biology teachers (Lederman, 1986). The Lederman sample scored consistently and significantly higher NSKS scores on every scale compared to the Zimbabwe sample in this study. Again null hypothesis $H_03$ is rejected.

Null hypothesis $H_04$ stating that BEd science teachers will have neither a negative nor a positive awareness of a societal issue, environmental conservation, was tested with data obtained using a researcher adapted environmental-conservation awareness scale (ECAS) (Chapter VII). The ECAS had 4 factors originally defined by Steiner (1973). The teachers had significantly positive environmental conservation awareness scores for factors I, II, and III. Their score on Factor IV 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. 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) and therefore $H_04$ is rejected.

The results of testing $H_05$ (Chapter V) which stated BEd science teachers will show equal preference for inquiry instructional ideology compared to non-inquiry instructional ideology was tested with data collected with 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). H05 is rejected.

Null hypothesis H06 stated that there will be no relationship between BEd science teachers' orientation to indigenous culture and their inquiry instructional ideology preference score, their environmental conservation awareness score, and their understanding of the nature of science score. Null hypothesis H07 predicted that there will be no relationship between BEd science teachers' instructional preferences and their environmental conservation awareness score. H08 stated that there will be no relationship between BEd science teachers' understanding of the nature of science and their environmental conservation awareness scores. The correlation matrix summarizing data for testing H06, H07, and H08 is in Chapter VI. A modest and non-significant negative correlation was obtained between the orientation to indigenous culture scores and either environmental conservation awareness scores, nature of scientific knowledge or nature of science scores, instructional preference for inquiry scores (p >> .05). H06 is retained. A significant positive relationship was found between orientation to indigenous culture scores and preference for traditional instructional ideology scores (r = .40) and between the teachers' environmental conservation awareness scores and the instructional preference for inquiry (.30) and nature of science scores (.27). Both H07 and H08 are rejected.

Null hypothesis H09 stated there will be no differences in BEd science teachers' (i) orientation to indigenous culture, (ii) instructional ideology, (iii) environmental conservation awareness, and (iv) understanding of the nature of science when the BEd science teachers are grouped according to personal, academic, professional, and socio-cultural characteristics. The homogenous nature of the sample made for extremely disproportionate cell sizes. Regardless, a
trial ANOVA was run and no significant differences (p = .05) were found in the BEd science teachers' perception of the nature of science or scientific knowledge, orientation to indigenous culture or instructional ideology, and environmental conservation awareness when grouped according to subject specialization, gender, age group, academic qualifications, teacher training program, professional qualifications, teaching experience, pre-service training college, vernacular language spoken, 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. No meaningful correlations were found between these factors and constructs of the study. H9 is tentatively rejected.

**Summary and discussion**

This study partly demonstrated that BEd science teachers' experience, observations and knowledge concerning the interaction of indigenous culture in Zimbabwe with science education is largely negative (Chapter IV). Their responses illustrated that their experience and belief was that indigenous experience and the basis or logic of explaining that experience was different and independent of scientific explanation and that the two thought systems are seemingly irreconcilable. If the experience of these teachers is anything to go by, it can be said that a scientific perception of reality is not part of the everyday cognitive and affective repertoire of indigenous students and in some cases those of science teachers in Zimbabwe. In fact, several others have also have 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). However, as Yakubu (1994) notes:

> this should not be construed to suggest that science and technology are incomprehensible to people in the developing countries. The suggestion is that spontaneous application of the scientific spirit learnt through the western form of education is lacking. There seem to be something which inhibits the spontaneous application of scientific ideas in problem situations. 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)
In this study 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 was that scientific ways of thinking had not become a spontaneous means to view and explain experiences. The results of this study support Cobb's (1993) 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" (p. 1). Teachers in the study were concerned with the ease with which any experience or observation not understood is assigned mystical qualities. A handful of respondents in this study raised a 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).

This study found that teachers' orientation to indigenous culture scores, although low (Chapter V), 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 world-view. Even for this youthful sample, item analysis profiles demonstrated teachers had some authoritarian perceptions, a tendency which was evident from their rating of the traditional subscale of the 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. It is 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 other similar 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 score (Chapter V). 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 \(r = -0.22, p = .05\). However, given the fact that the socio-cultural context has authoritarian tendencies which may not be supportive of 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 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 her 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; no page number)

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 results in Chapter VI show that the BEd sample did not perceive scientific knowledge as parsimonious and that they believed in a single scientific method with 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 BEd 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 A 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. In Chapter III some evidence was reported which showed that 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 does not incorporate 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 science and technology 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. 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). Cobern (1989) notes that 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/or 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 (Chapter VII).

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. There is 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. There is need to employ methodologies which overcome limitations associated with the use of surveys (Ary, et al., 1990). For example, respondents may not accurately report their perceptions and beliefs and thus triangulation with observation data is necessary.

A major limitation of the present study is that no treatment variables were manipulated, therefore correlations and relationships reported are non-causal. This raises the need for research which utilizes qualitative techniques to look at the socio-cultural variables raised in this study. Further research must try to establish a model of causal relationships and validate those relationships against observation data on how teachers implement their knowledge and beliefs in classrooms. Future research must also use a more representative sample of teachers; the present sample consists of a select group of teachers reading for a degree. In Zimbabwe, pre-service science teacher training and the majority of in-service programs are at the non-graduate level. Graduate science teachers represent only a small percent of certified science teachers and thus the results of this study may not generalize to all secondary science teachers in Zimbabwe. Relatively young teachers in this study had relatively low orientation to indigenous cultural values and a high inquiry instructional ideology. Much older teachers are expected to have higher levels of orientation to indigenous culture and are more likely to have higher orientation to traditional instructional methods. This study also demonstrated that there was a discrepancy between some views of science held by science teachers and those expressed in accepted models of the nature of science. Teachers who are older and who have not received degree level training in science may have inadequate conceptions of the nature of science. A random heterogeneous sample of science teachers might reveal that socio-cultural factors and commitment to traditional cultural values and beliefs have a much more important relationship with scientific literacy constructs than found in this study.
REFERENCES


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At Iowa State University my gratitude goes to my Program of Study Committee comprising of Professors Robert Angelici, Lynn W. Glass, Mary E. Huba, Michael R. Simonson, and Ann E. Thompson who gave expert guidance, encouragement, and direction to my academic studies and research. I thank my major advisor Professor Lynn W. Glass for guidance, for his general ready availability, and for allowing me access to his personal library science education journals and books. I thank the Department of Curriculum and Instruction for offering me office space and for the professional support I got from all the faculty and staff I interacted with. I found the departmental secretaries Jan Luiken and Joy King very helpful and ready to assist whenever they could. Thanks also go to Mr. J. Akpan for serving as second analyst on the qualitative data.

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I am very grateful for the support I got from friends and relatives in Zimbabwe particularly Rachel and Sheunesu Tembo and my parents Lillian and James Chipunza. Finally, I express my gratitude to my immediate family, wife, Thokozile, and the boys Farirai Thokozani and Shingirirayi Fungayi for their patience, support, and living true to their names. Indeed, more people than can be mentioned here contributed to the success of this work; I thank them all anonymously.
APPENDIX: SUPPLEMENTARY DATA TABLES

Table A1. Item analysis of responses to the orientation to indigenous culture scale (OICS)
Table A2. Item analysis of responses to the nature of scientific knowledge scale (NSKS)
Table A3. Comparison of NOSS profiles for Zimbabwean, Nigerian and American samples
### Table A1. Item analysis of responses to the orientation to indigenous culture scale [OICS] (N = 63)

<table>
<thead>
<tr>
<th>OICS Itema</th>
<th>Disagree %</th>
<th>Uncertain %</th>
<th>Agree %</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex role stereotyping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Laboratory work must be analyzed and the tasks differentiated into those suited for boys or girls.</td>
<td>87.30</td>
<td>1.59</td>
<td>11.11</td>
<td>1.75</td>
<td>1.14</td>
</tr>
<tr>
<td>7. 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.</td>
<td>6.35</td>
<td>1.59</td>
<td>92.06</td>
<td>4.49</td>
<td>0.98</td>
</tr>
<tr>
<td>25. Teachers should make clear how the sexes differ by emphasizing differentiated roles, tasks, and duties.</td>
<td>77.78</td>
<td>1.59</td>
<td>20.63</td>
<td>2.06</td>
<td>1.15</td>
</tr>
<tr>
<td>27. It is prudent for teachers to expect and encourage both boys and girls to work equally enthusiastically towards lesson objectives.</td>
<td>18.03</td>
<td>1.64</td>
<td>80.33</td>
<td>4.12</td>
<td>1.36</td>
</tr>
<tr>
<td>32. Looking to the future, science education will be equally useful to boys and girls.</td>
<td>6.35</td>
<td>1.59</td>
<td>92.06</td>
<td>4.59</td>
<td>0.87</td>
</tr>
<tr>
<td><strong>Respect for Authority Figures</strong></td>
<td></td>
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</tr>
<tr>
<td>1. The teacher has a role to ensure that pupils' behavior conforms to that expected of them by elders without questioning.</td>
<td>50.79</td>
<td>4.76</td>
<td>44.45</td>
<td>2.90</td>
<td>1.24</td>
</tr>
<tr>
<td>15. If the opinion of a younger person differs from that of the older people then the younger person's opinion is inconsequential.</td>
<td>87.30</td>
<td>3.17</td>
<td>9.52</td>
<td>1.71</td>
<td>1.02</td>
</tr>
<tr>
<td>29. The individual is in the first place a member of the community, (s)he must serve and conform to it.</td>
<td>9.52</td>
<td>9.52</td>
<td>80.96</td>
<td>4.03</td>
<td>0.95</td>
</tr>
<tr>
<td>37. Children today are boisterous and undisciplined, they lack respect for authority figures.</td>
<td>39.68</td>
<td>12.70</td>
<td>47.52</td>
<td>3.13</td>
<td>1.14</td>
</tr>
<tr>
<td>40. If a young person recognized inconsistencies or irregularity in the logic of elders, it would be disrespectful or bad-mannered to point them out.</td>
<td>88.89</td>
<td>1.59</td>
<td>9.52</td>
<td>1.94</td>
<td>0.93</td>
</tr>
<tr>
<td>42. Young persons' actions and manners today differ from my expectations of a cultured person.</td>
<td>25.39</td>
<td>7.94</td>
<td>66.67</td>
<td>3.40</td>
<td>1.01</td>
</tr>
<tr>
<td><strong>Religious ideology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I have a personal concern that my religious beliefs are not congruent with the scientific world-view I have to teach.</td>
<td>59.01</td>
<td>8.20</td>
<td>32.79</td>
<td>2.51</td>
<td>1.34</td>
</tr>
<tr>
<td>12. It is unlikely that natural calamities such as drought and floods are infliction or punishment on society by angry tribal spirits who should be appeased.</td>
<td>31.75</td>
<td>19.05</td>
<td>49.21</td>
<td>3.29</td>
<td>1.43</td>
</tr>
<tr>
<td>18. It is all right for people to raise questions about even the most sacred religious matters of Zimbabwe's traditional culture.</td>
<td>15.87</td>
<td>7.94</td>
<td>76.19</td>
<td>3.81</td>
<td>1.09</td>
</tr>
<tr>
<td>20. Failure to appease one's ancestors usually leads them to withdraw vital protection resulting in illness or other misfortune in the family.</td>
<td>57.14</td>
<td>26.98</td>
<td>15.88</td>
<td>2.38</td>
<td>1.13</td>
</tr>
</tbody>
</table>

aItems numbers as they randomly placed on the OICS.
Table A1. (Continued)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>22. When someone challenges my traditional beliefs, it is my immediate responsibility to convince them to change their perspectives so that they match my own.</td>
<td>63.49</td>
<td>9.52</td>
<td>26.99</td>
<td>2.49</td>
<td>1.18</td>
</tr>
<tr>
<td>26. Things that happen in our lives may be caused by another person or by an ancestor.</td>
<td>49.20</td>
<td>22.22</td>
<td>28.56</td>
<td>2.56</td>
<td>1.27</td>
</tr>
<tr>
<td>5. One problem with nuclear families is that traditional religious practices become negated.</td>
<td>34.82</td>
<td>15.87</td>
<td>49.21</td>
<td>3.13</td>
<td>1.21</td>
</tr>
<tr>
<td>10. Efforts should be made to keep extended families so that the moral fabric can be preserved.</td>
<td>30.16</td>
<td>11.11</td>
<td>58.73</td>
<td>3.27</td>
<td>1.29</td>
</tr>
<tr>
<td>24. Family planning programs restrict individual families’ right to have as many children as possible.</td>
<td>68.25</td>
<td>9.52</td>
<td>22.23</td>
<td>2.24</td>
<td>1.24</td>
</tr>
<tr>
<td>28. Even if one works and lives in an urban center/town, it is imperative to maintain a rural home.</td>
<td>27.42</td>
<td>16.13</td>
<td>56.45</td>
<td>3.45</td>
<td>1.11</td>
</tr>
<tr>
<td>36. Population growth is a growing problem in Zimbabwe, it is irresponsible to have as many children as possible.</td>
<td>15.17</td>
<td>0.00</td>
<td>84.13</td>
<td>4.02</td>
<td>1.13</td>
</tr>
<tr>
<td>4. An individual’s effort without ancestral blessing may not be enough to succeed in one’s endeavors.</td>
<td>71.43</td>
<td>17.46</td>
<td>11.11</td>
<td>2.00</td>
<td>1.11</td>
</tr>
<tr>
<td>17. If an accident e.g. car crash results in serious injury or a death of a person, it is not necessary to seek divine guidance to ascertain just how that particular person was the target.</td>
<td>15.87</td>
<td>9.52</td>
<td>74.60</td>
<td>3.89</td>
<td>1.11</td>
</tr>
<tr>
<td>19. When a family member is inflicted with disease, it is not logical to find out who sent the disease.</td>
<td>26.98</td>
<td>9.52</td>
<td>63.49</td>
<td>3.52</td>
<td>1.34</td>
</tr>
<tr>
<td>33. When there is a serious sickness or death in the family, some bad person or evil spirit caused it.</td>
<td>71.43</td>
<td>15.87</td>
<td>12.70</td>
<td>2.03</td>
<td>1.03</td>
</tr>
<tr>
<td>35. Those persons who have harmonious relationships with their ancestral spirits have greater opportunities to succeed in life.</td>
<td>55.55</td>
<td>33.33</td>
<td>11.12</td>
<td>2.29</td>
<td>1.08</td>
</tr>
</tbody>
</table>

View of natural environment

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</thead>
<tbody>
<tr>
<td>3. Exploiting nature must be done in consultation with elders who must appease the relevant spirits.</td>
<td>65.08</td>
<td>17.46</td>
<td>17.46</td>
<td>2.17</td>
<td>1.23</td>
</tr>
<tr>
<td>6. Large scale collection and sale of wild fruit for profit is one way humans have diminished the sacredness and religious significance of nature.</td>
<td>47.62</td>
<td>14.29</td>
<td>38.09</td>
<td>2.76</td>
<td>1.24</td>
</tr>
<tr>
<td>13. Nature is not an impersonal object or phenomenon, rather, it is sacred and filled with religious significance e.g. presence of spirits.</td>
<td>44.44</td>
<td>26.99</td>
<td>28.57</td>
<td>2.68</td>
<td>1.19</td>
</tr>
<tr>
<td>14. Nature must be exploited only to a level necessary to satisfy the subsistence needs of the people rather than be turned into a source of commercial profit.</td>
<td>49.20</td>
<td>4.76</td>
<td>46.03</td>
<td>2.97</td>
<td>1.39</td>
</tr>
</tbody>
</table>
Table A1. (Continued)

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<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>38. There is a need to live in harmony with nature and other living things rather than seek to explore and subjugate them.</td>
<td>32.79</td>
<td>8.20</td>
<td>59.01</td>
<td>3.38</td>
</tr>
<tr>
<td>9. Pupils must accept facts as they are presented to them, expressing doubt is a sign of disrespect.</td>
<td>95.23</td>
<td>0.00</td>
<td>4.77</td>
<td>1.43</td>
</tr>
<tr>
<td>11. In solving problems it is unnecessary that students get the expected or right answers to successfully complete the activity.</td>
<td>38.71</td>
<td>1.61</td>
<td>59.68</td>
<td>3.39</td>
</tr>
<tr>
<td>21. While a spirit of questioning is good, there are many aspects of our lives and beliefs which should be accepted as they are.</td>
<td>52.38</td>
<td>11.11</td>
<td>36.51</td>
<td>2.76</td>
</tr>
<tr>
<td>30. Direct presentation of ideas for solving problems by the teacher is to be preferred since in society children generally learn by being told.</td>
<td>80.95</td>
<td>1.59</td>
<td>17.46</td>
<td>2.08</td>
</tr>
<tr>
<td>16. Modern technology such as radio and television has contributed more to the moral decay of traditional culture than to its progress.</td>
<td>36.51</td>
<td>11.11</td>
<td>52.38</td>
<td>3.21</td>
</tr>
<tr>
<td>23. There is no logic in trying to change the way traditional values and beliefs are in Zimbabwe.</td>
<td>61.29</td>
<td>14.52</td>
<td>24.19</td>
<td>2.47</td>
</tr>
<tr>
<td>31. 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.</td>
<td>87.30</td>
<td>3.17</td>
<td>9.52</td>
<td>1.89</td>
</tr>
<tr>
<td>34. A scientific perception of reality can develop in a society with largely traditional perspectives.</td>
<td>40.68</td>
<td>10.17</td>
<td>49.15</td>
<td>3.14</td>
</tr>
<tr>
<td>39. I believe that there are teachings from other cultures which are valid if adopted or adapted to our own way of life.</td>
<td>7.94</td>
<td>1.59</td>
<td>90.47</td>
<td>4.11</td>
</tr>
<tr>
<td>41. I find the pace of social change to be rapid to the extent that it is difficult for me to cope with it.</td>
<td>74.60</td>
<td>7.94</td>
<td>17.46</td>
<td>2.35</td>
</tr>
</tbody>
</table>

*Items numbers as they randomly placed on the OICS.*
### Table A2. Item analysis of responses to the nature of scientific knowledge scale [NSKS] (N = 63)

<table>
<thead>
<tr>
<th>NSKS Dimension</th>
<th>% Disagree</th>
<th>% Uncertain</th>
<th>% Agree</th>
<th>Mean</th>
<th>S.D.</th>
<th>d-Score (^a)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amoral</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The applications of scientific knowledge can be judged good or bad, but the knowledge itself cannot.</td>
<td>12.90</td>
<td>9.68</td>
<td>77.42</td>
<td>3.89</td>
<td>0.93</td>
<td>+ 0.89</td>
<td>7.55***</td>
</tr>
<tr>
<td>5. It is incorrect to judge a piece of scientific knowledge as being good or bad.</td>
<td>45.17</td>
<td>8.06</td>
<td>46.77</td>
<td>3.11</td>
<td>1.19</td>
<td>+ 0.11</td>
<td>0.75</td>
</tr>
<tr>
<td>7. Certain pieces of scientific knowledge are good and bad.</td>
<td>37.10</td>
<td>16.13</td>
<td>46.77</td>
<td>3.11</td>
<td>1.13</td>
<td>+ 0.11</td>
<td>+ 0.79</td>
</tr>
<tr>
<td>8. Even if the applications of a scientific theory are judged to be good, we should not judge the theory itself.</td>
<td>41.94</td>
<td>11.29</td>
<td>46.77</td>
<td>3.13</td>
<td>1.15</td>
<td>+ 0.13</td>
<td>0.88</td>
</tr>
<tr>
<td>18. Moral judgment can be passed on scientific knowledge.</td>
<td>36.07</td>
<td>18.03</td>
<td>45.90</td>
<td>3.08</td>
<td>1.08</td>
<td>+ 0.08</td>
<td>+ 0.59</td>
</tr>
<tr>
<td>21. It is meaningful to pass moral judgment on both the applications of scientific knowledge and on the knowledge itself.</td>
<td>22.58</td>
<td>14.52</td>
<td>62.90</td>
<td>3.40</td>
<td>0.90</td>
<td>+ 0.40</td>
<td>+ 3.55***</td>
</tr>
<tr>
<td>36. If the applications of a piece of scientific knowledge are generally considered bad, then the piece of knowledge is also considered to be bad.</td>
<td>69.35</td>
<td>11.29</td>
<td>19.36</td>
<td>2.40</td>
<td>1.06</td>
<td>- 0.40</td>
<td>- 4.42***</td>
</tr>
<tr>
<td>48. A piece of scientific knowledge should not be judged good or bad.</td>
<td>45.17</td>
<td>17.74</td>
<td>37.09</td>
<td>2.98</td>
<td>0.82</td>
<td>- 0.02</td>
<td>- 0.11</td>
</tr>
<tr>
<td><strong>Creative</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Scientific laws, theories and concepts do not express creativity.</td>
<td>74.19</td>
<td>11.29</td>
<td>14.51</td>
<td>2.18</td>
<td>1.00</td>
<td>- 0.82</td>
<td>- 6.47***</td>
</tr>
<tr>
<td>17. Scientific knowledge expresses the creativity of scientists.</td>
<td>9.68</td>
<td>9.68</td>
<td>80.64</td>
<td>3.87</td>
<td>0.86</td>
<td>+ 0.87</td>
<td>7.99***</td>
</tr>
<tr>
<td>20. Scientific laws, theories and concepts express creativity.</td>
<td>14.52</td>
<td>8.06</td>
<td>77.42</td>
<td>3.76</td>
<td>0.97</td>
<td>+ 0.76</td>
<td>6.15***</td>
</tr>
<tr>
<td>23. Scientific knowledge is not a product of human imagination.</td>
<td>54.84</td>
<td>6.45</td>
<td>38.71</td>
<td>2.81</td>
<td>1.27</td>
<td>- 0.19</td>
<td>- 1.20</td>
</tr>
<tr>
<td>28. A scientific theory is similar to a work of art in that they both express creativity.</td>
<td>20.96</td>
<td>8.06</td>
<td>70.98</td>
<td>3.47</td>
<td>1.05</td>
<td>+ 0.47</td>
<td>3.50***</td>
</tr>
<tr>
<td>32. Scientific knowledge is a product of human imagination.</td>
<td>40.32</td>
<td>6.45</td>
<td>53.23</td>
<td>3.13</td>
<td>1.27</td>
<td>+ 0.13</td>
<td>0.79</td>
</tr>
<tr>
<td>34. Scientific knowledge does not express the creativity of scientists.</td>
<td>85.49</td>
<td>4.84</td>
<td>9.67</td>
<td>2.05</td>
<td>0.86</td>
<td>- 0.95</td>
<td>- 8.74***</td>
</tr>
</tbody>
</table>

* \( p < .05 \)

*** \( p < .001 \)

\(^a\) The d-Score = score obtained by subtracting neutral score for that scale or subscale from its scale or subscale score. The neutral score is obtained by multiplying the number of items in that scale or subscale by a value of '3'.
Table A2. (Continued)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Score1</th>
<th>Score2</th>
<th>Score3</th>
<th>Score4</th>
<th>Score5</th>
<th>Score6</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. Scientific theories are discovered, not created by humans.</td>
<td>24.20</td>
<td>6.45</td>
<td>69.35</td>
<td>3.58</td>
<td>1.14</td>
<td>0.58</td>
</tr>
<tr>
<td>Development</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>16. We accept scientific knowledge even though it may contain error.</td>
<td>46.77</td>
<td>6.45</td>
<td>69.35</td>
<td>2.87</td>
<td>1.15</td>
<td>-0.13</td>
</tr>
<tr>
<td>25. The truth of scientific knowledge is beyond doubt.</td>
<td>43.54</td>
<td>11.29</td>
<td>45.17</td>
<td>2.95</td>
<td>1.14</td>
<td>-0.05</td>
</tr>
<tr>
<td>26. Today's scientific laws, theories and concepts may have to be changed in the face of new evidence.</td>
<td>12.90</td>
<td>3.23</td>
<td>83.87</td>
<td>3.98</td>
<td>1.06</td>
<td>0.98</td>
</tr>
<tr>
<td>27. We do not accept a piece of scientific knowledge unless it is free of error.</td>
<td>51.61</td>
<td>11.29</td>
<td>37.10</td>
<td>2.84</td>
<td>1.10</td>
<td>-0.16</td>
</tr>
<tr>
<td>31. Scientific beliefs do not change over time.</td>
<td>75.41</td>
<td>4.92</td>
<td>19.67</td>
<td>2.28</td>
<td>1.02</td>
<td>-0.72</td>
</tr>
<tr>
<td>37. Scientific knowledge is subject to review and change.</td>
<td>6.46</td>
<td>0.00</td>
<td>93.54</td>
<td>4.19</td>
<td>0.87</td>
<td>1.19</td>
</tr>
<tr>
<td>42. Those scientific beliefs which were accepted in the past and since have been discarded should be judged in their historical context.</td>
<td>19.35</td>
<td>12.90</td>
<td>67.75</td>
<td>3.53</td>
<td>1.07</td>
<td>0.47</td>
</tr>
<tr>
<td>43. Scientific knowledge is unchanged.</td>
<td>90.32</td>
<td>1.61</td>
<td>8.07</td>
<td>1.85</td>
<td>0.92</td>
<td>-1.15</td>
</tr>
<tr>
<td>Parsimonious</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Scientific knowledge is stated as simply as possible.</td>
<td>38.71</td>
<td>4.84</td>
<td>56.45</td>
<td>3.18</td>
<td>1.11</td>
<td>0.18</td>
</tr>
<tr>
<td>6. If two scientific theories explain a scientist's observations equally well, the simpler theory is chosen.</td>
<td>29.03</td>
<td>11.29</td>
<td>59.68</td>
<td>3.42</td>
<td>1.03</td>
<td>0.42</td>
</tr>
<tr>
<td>14. Scientific laws, theories and concepts are not stated as simply as possible.</td>
<td>64.51</td>
<td>6.45</td>
<td>29.03</td>
<td>2.45</td>
<td>1.11</td>
<td>0.55</td>
</tr>
<tr>
<td>15. There is an effort in science to build as great a number of laws, theories and concepts as possible.</td>
<td>24.20</td>
<td>12.90</td>
<td>62.90</td>
<td>3.42</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>29. There is an effort in science to keep the number of laws, theories and concepts at a minimum.</td>
<td>59.68</td>
<td>20.97</td>
<td>19.35</td>
<td>2.48</td>
<td>1.04</td>
<td>-0.52</td>
</tr>
<tr>
<td>39. If two scientific theories explain a scientist's observations equally well, the more complex theory is chosen.</td>
<td>85.48</td>
<td>4.84</td>
<td>9.68</td>
<td>2.08</td>
<td>0.77</td>
<td>-0.92</td>
</tr>
<tr>
<td>40. Scientific knowledge is specific as opposed to comprehensive.</td>
<td>29.03</td>
<td>20.97</td>
<td>50.00</td>
<td>3.24</td>
<td>0.97</td>
<td>0.24</td>
</tr>
<tr>
<td>46. Scientific knowledge is comprehensive as opposed to specific.</td>
<td>48.33</td>
<td>20.00</td>
<td>33.67</td>
<td>2.82</td>
<td>1.11</td>
<td>-0.18</td>
</tr>
</tbody>
</table>
Table A2. (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Testable</th>
<th>Unified</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Scientific knowledge need not be capable of experimental test.</td>
<td>70.97</td>
<td>6.45</td>
</tr>
<tr>
<td>11. Consistency among test results is not a requirement for the acceptance of scientific knowledge.</td>
<td>80.64</td>
<td>6.45</td>
</tr>
<tr>
<td>12. A piece of scientific knowledge will be accepted if the evidence can be obtained by other investigators working under similar conditions.</td>
<td>12.90</td>
<td>0.00</td>
</tr>
<tr>
<td>13. The evidence for scientific knowledge need not be open to public examination.</td>
<td>83.87</td>
<td>3.23</td>
</tr>
<tr>
<td>22. The evidence for scientific knowledge must be repeatable.</td>
<td>8.07</td>
<td>1.61</td>
</tr>
<tr>
<td>33. The evidence for a piece of scientific knowledge does not have to be repeatable.</td>
<td>95.16</td>
<td>1.61</td>
</tr>
<tr>
<td>38. Scientific laws, theories and concepts are tested against reliable observations.</td>
<td>6.45</td>
<td>0.00</td>
</tr>
<tr>
<td>45. Consistency among test results is a requirement for the acceptance of scientific knowledge.</td>
<td>6.46</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Unified

3. The laws, theories and concepts of biology, chemistry and physics are related. | 6.45 | 3.23 | 90.32 | 4.10 | 0.74 | +1.10 | 11.67*** |

10. The laws, theories and concepts of biology, chemistry and physics are not linked. | 90.32 | 4.84 | 4.84 | 1.82 | 0.74 | -1.18 | -12.60*** |

19. The laws, theories and concepts of biology, chemistry and physics are not related. | 93.54 | 3.23 | 3.23 | 1.79 | 0.66 | -1.21 | -14.51*** |

24. Relationships among the laws, theories, and concepts of science do not contribute to the explanatory and predictive power of science. | 87.10 | 3.23 | 9.67 | 2.11 | 0.79 | -0.89 | -8.82*** |

30. The various sciences contribute to a single organized body of knowledge. | 8.06 | 0.00 | 91.94 | 4.02 | 0.71 | +1.02 | 11.23*** |

35. Biology, chemistry and physics are similar kinds of knowledge. | 40.33 | 6.45 | 53.22 | 3.11 | 1.04 | +0.11 | 0.85 |

44. Biology, chemistry and physics are different kinds of knowledge. | 58.06 | 3.23 | 38.71 | 2.76 | 1.13 | -0.24 | -1.69* |

47. The laws, theories and concepts of biology, chemistry and physics are interwoven. | 8.06 | 6.45 | 85.49 | 3.95 | 0.82 | +0.95 | 9.16*** |
Table A3. Comparison of NOSS profiles for Zimbabwean, Nigerian and American samples

<table>
<thead>
<tr>
<th>Nature of Science Scale Itemsa</th>
<th>Zimbabwe (n = 63)</th>
<th>American (n = 21)</th>
<th>Nigeria (n = 32)</th>
<th>bD– Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total NOSS–score</td>
<td>48.38</td>
<td>58.10</td>
<td>49.50</td>
<td>-9.72</td>
</tr>
<tr>
<td>1. The most important scientific ideas have been the result of a systematic process of logical thought [D].</td>
<td>1.38</td>
<td>0.57</td>
<td>1.60</td>
<td>0.49</td>
</tr>
<tr>
<td>2. Classification schemes are imposed upon nature by the scientists, they are not inherent in the materials classified [A].</td>
<td>1.90</td>
<td>0.80</td>
<td>1.90</td>
<td>0.81</td>
</tr>
<tr>
<td>3. Thanks to discovery of the scientific method, new discoveries in science have begun to come faster [D].</td>
<td>1.40</td>
<td>0.57</td>
<td>1.70</td>
<td>0.64</td>
</tr>
<tr>
<td>4. The primary objective of the working scientist is to improve human welfare [D]</td>
<td>1.08</td>
<td>0.11</td>
<td>1.60</td>
<td>0.81</td>
</tr>
<tr>
<td>5. While a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is permanent [D].</td>
<td>1.51</td>
<td>0.67</td>
<td>2.10</td>
<td>0.81</td>
</tr>
<tr>
<td>6. The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator [D].</td>
<td>2.48</td>
<td>0.64</td>
<td>2.50</td>
<td>0.64</td>
</tr>
<tr>
<td>7. Science is constantly working toward more detailed and complex knowledge [D].</td>
<td>1.33</td>
<td>0.48</td>
<td>1.70</td>
<td>0.81</td>
</tr>
<tr>
<td>8. A fundamental principle of science is that discoveries and research should have some practical applications [D].</td>
<td>1.15</td>
<td>0.26</td>
<td>2.00</td>
<td>0.81</td>
</tr>
<tr>
<td>9. While biologists use the deductive approach to a problem, physicist always work inductively [D].</td>
<td>1.90</td>
<td>0.70</td>
<td>2.40</td>
<td>0.36</td>
</tr>
</tbody>
</table>

a Letter following the NOSS–items indicates the expected Kimball model response agree [A] or disagree [D].

b This is a deviation score obtained by subtracting the Zimbabwean score from the American sample score. There is no significant difference between the Zimbabwean and Nigerian samples.

c The mean score for each item was obtained after re–coding the items where a disagree response was expected. The Zimbabwean mean total score was significantly lower than that for the American sample (t(df 27 = -5.63 p < .05). The mean total score of the Zimbabwean sample was also significantly less like the Kimball model response score.
Table A3. (continued)

10. The ultimate goal of all science is to reduce observations and phenomena to a collection of mathematical relationships [A].

11. The best definition of science would be an "organized body of knowledge" [D].

12. Science tries mainly to develop new machines and processes for the betterment of humankind [D].

13. Any scientific research broader than a single specialist can only be carried out through the use of a team of researchers from various relevant fields [D].

14. Investigation of the possibilities of creating life in the laboratory is an invasion of science into areas where it does not belong [D].

15. Team research is more productive than individual research [D].

16. Many scientific models are human-made and do not pretend to represent reality [A].

17. Scientific investigations follow definite approved procedures [D].

18. Most scientists are reluctant to share their findings with foreigners, being mindful of the problem of national security [D].

19. The essential test of scientific theory is its ability to correctly predict future events [A].

20. When a large number of observations have shown results consistent with a general rule, this generalization is considered to be a universal law of nature [D].

21. The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it [D].

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.67</td>
<td>0.74</td>
<td>1.30</td>
<td>0.49</td>
<td>1.60</td>
</tr>
<tr>
<td>1.86</td>
<td>0.12</td>
<td>2.20</td>
<td>0.81</td>
<td>1.80</td>
</tr>
<tr>
<td>1.30</td>
<td>2.20</td>
<td>0.81</td>
<td>1.50</td>
<td>0.81</td>
</tr>
<tr>
<td>1.49</td>
<td>0.67</td>
<td>2.30</td>
<td>0.81</td>
<td>1.40</td>
</tr>
<tr>
<td>2.62</td>
<td>0.53</td>
<td>2.50</td>
<td>0.64</td>
<td>2.30</td>
</tr>
<tr>
<td>1.46</td>
<td>0.54</td>
<td>1.90</td>
<td>0.64</td>
<td>1.80</td>
</tr>
<tr>
<td>1.56</td>
<td>0.65</td>
<td>1.90</td>
<td>0.81</td>
<td>1.70</td>
</tr>
<tr>
<td>1.68</td>
<td>0.83</td>
<td>1.80</td>
<td>0.81</td>
<td>1.80</td>
</tr>
<tr>
<td>2.13</td>
<td>0.85</td>
<td>2.60</td>
<td>0.49</td>
<td>1.80</td>
</tr>
<tr>
<td>2.25</td>
<td>0.84</td>
<td>2.40</td>
<td>0.64</td>
<td>2.40</td>
</tr>
<tr>
<td>1.18</td>
<td>0.25</td>
<td>1.80</td>
<td>0.81</td>
<td>1.30</td>
</tr>
<tr>
<td>1.13</td>
<td>0.24</td>
<td>1.20</td>
<td>0.25</td>
<td>1.20</td>
</tr>
</tbody>
</table>
22. One of the distinguishing traits of science is that it recognizes its own limitations [A].

23. The steam engine was one of the earliest and most important developments of modern science [D].

24. Scientific research should be given credit for producing such things as modern refrigerators, television, and home air-conditioning [D].

25. If at some future date it is found that electricity does not consist of electrons, today's practices in designing electrical apparatus will have to be discarded [D].

26. By application of the scientific method, step by step, humans can solve almost any problem or answer any question in the realm of nature [D].

27. Scientific method is a myth which is usually read into the story after it has been completed [A].

28. Scientific work requires a dedication that excludes many aspects of the lives of people in other fields of work [D].

29. An important characteristic of the scientific enterprise is its emphasis on the practical [D].

<p>| | | | |</p>
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