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Effect of teachers' and students' worldviews on learning of O-level chemistry at a school in Harare, Zimbabwe

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Abstract

This study investigated the relationship between students' and teachers' enacted worldviews and school culture, and the extent to which cultural beliefs, values and norms and religion influence the teaching and learning of chemistry at a school in Harare. Interviews, observations, and discussions involving students in forms 3 and 4 and their teachers were conducted to study the potential of teachers to help students negotiate cultural borders in the learning of chemistry. Church leaders and community elders were also interviewed to establish their possible influence on the views of the teachers and students. Teachers' and students' views on traditional medicine and nature and on traditional medicine and chemistry were used as criteria to match teachers' and students' worldviews. It appeared that the worldviews of teachers and students were not sufficiently compatible to permit teachers to effectively assist students to negotiate cultural borders. However, the religious and cultural views the participants brought into the classroom did not have much influence on the teaching of O-level chemistry at this school. Notwithstanding, teachers did not attempt to include community experiences as appropriate prior knowledge. But, all the same, the worldviews of the participants did not appear to be relevant to chemistry learning at the level in question.

Keywords: *Community science, enacted scientific worldviews, cultural border-crossing, chemistry teaching, misconceptions*

Background

Studying science can pose major cultural problems, even for pupils who come from western cultures (Costa, 1995; Aikenhead, 1997). Pupils experience at least two types of culture when they study science in a formal western-type school setting: the culture of school science and the culture of their life-world (Jegede and Aikenhead, 1999). Students and teachers enter the classroom with different concepts based on their respective cultural backgrounds. Students bring concepts derived from their community-based culture and use their prior knowledge and experience to make their own meaning as they interact with the teachers' delivery (Gagnon and Collay, 2006). The different cultural beliefs, values, norms and ideas the teachers and students bring

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to the classroom will form what are referred to as enacted scientific worldviews (Cobern and Loving, 2000). The way each constructs meaning in his/her encounters with nature differs for each of them. Thus, there will be as many worldviews taken into the classroom as there are the participants (*i.e.* students and teachers) and this will influence the way students understand new concepts.

There are bound to be cultural conflicts if the cultural beliefs of the participants are not in agreement, and meaningful learning will not take place (Aikenhead and Jegede, 2000; Novak, 1977). The enacted worldviews brought to the classroom form a vast conceptual ecology which, for each student, is a result of socialization in families, religion, tradition and culture and leads to worldviews which are different from western science (Kearney, 1984; Cobern, 1991; Cobern and Loving, 2000; Jegede and Aikenhead, 2000). Scientific phenomena and concepts that are not part of the students' conceptual ecology must be carefully explained using suitable language, methodology and textbooks that facilitate conceptual change; avoid or correct misconceptions; avoid conceptual conflicts and ensure that the student does not exist parallel to school culture. Students must travel from their everyday life-world to the world of science as they acquire the culture of science found in the classroom. Success in the border crossing will be dependent on how effectively they are assisted in making the border crossing negotiations easier (Ogunniyi, 1988; Cobern, 1994; Jegede, 1995; Jegede and Aikenhead, 1999; Aikenhead and Jegede, 2000).

Most conventional lesson planning models are based on verbal explanations or visual demonstrations of a procedure or skill by the teacher. The students then combine these with their prior knowledge and practice as they make their own meaning and construct knowledge (Gagnon and Collay, 2006). Use of materials the students are familiar with will assist meaningful learning, as the learner's existing knowledge will then interact more readily with the new learning and avoid rote learning (West and Fensham, 1974).

The problems associated with border crossing may be compounded by informal meaning and misconceptions. Misconception implies the existence of concepts and terms which are faulty or even wrongly understood by the student, but which the student considers to be firm and correct knowledge. Thus teachers should be reliably informed about students' prior knowledge, especially that which works against proper assimilation of the desired information, for example informal meanings and misconceptions (Love, 1993).

Lack of appropriate teaching resources to be able to give quality and relevant chemistry education in schools is a common concern of many teachers, particularly in the third world countries. There is heavy reliance on improvised teaching resources that are dependent on the teachers' enacted scientific worldviews to define, select and organize information to deliver to students (Romanowski, 1998). Students build their cognitive structures based on their understanding and may construct concepts which sometimes differ from those held by the general scientific community (Nakhleh, 1992); or may fail to construct concepts which are congruent with what scientists believe (Novak, 1977, 2002). Careful selection of enacted worldviews will help students compare and bridge the worldviews of science and their own enacted worldviews; construct and reconstruct their individual conceptual frameworks and their attitudes toward science in ways that increase their cognitive competence. The teachers need recognize that only the learner can choose to learn meaningfully and to consciously and deliberately reconstruct his/her cognitive framework, as they help students correct misconceptions and assist meaningful learning. Learners base their understanding of new concepts on the knowledge and experiences that they already have (Ausubel, 1963; Bodner, 1986, Novak, 1977, 2002). Students find curriculum

science inaccessible if what they already know and the new knowledge do not relate and if the teaching materials do not provide meaningful context. Thus, use of aids the student is familiar with will assist learning.

Teaching should be structured so as to improve teachers' culture brokering skills so that teachers successfully assist students cross cultural borders between their community's culture and the culture of school science (Aikenhead, 2002). Fenwick (2000) says that a teacher in an indigenous society may be envisaged as (1) communicator-assisting in naming and renaming and making use of appropriate language, (2) a story maker –tracing and recording the interactions between the learner and the learned, and (3) an interpreter –helping learners make sense of the emerging patterns understanding their environment. The western scientific perspective may harmonize with the teacher's enacted worldview but the students enacted worldview in the non industrialized third world countries likely do not harmonize with the western worldview. Hence school science would be foreign to the student and integration of school science with the students' enacted science would appear like cultural imperialism/ colonialism. Although the traditional ecological knowledge of indigenous peoples is scientific in that it is empirical, experimental and systematic, it differs from western science in that it is localized and social, whereas western science is about the discovery of universal laws (Bapttiste and Barman, 1995; Aikenhead, 1997; Cobern, 2000).

Research questions

1. What scientific worldviews do teachers and students bring to the classroom, and to what extent do they influence the teaching and learning of chemistry at this school?
2. How are these scientific worldviews related to the teaching and learning of chemistry?
3. What challenges are met by teachers and students in cultural border crossing in learning chemistry at this school?

Delimitations of the study

The study was carried out at a school in one of the High Density Suburbs of Harare, Zimbabwe (2007) and involved O-level chemistry students (six boys and six girls), all four of the teachers who taught chemistry at the school (all males), two A-level students, four leaders of church denominations, and four community elders of at least 50 years of age, thus using a purposive sampling technique, limiting selection to those who had potential to provide relevant and useful information (Miles and Hubermann, 1984; Bogdan and Biklen, 1998; Nyawaranda, 1999). All participants in this study resided in the same community, consisting of three suburbs.

About 80% of the houses in these suburbs were initially allocated to people who were employed in the formal sector, about 10% were allocated to general workers and the rest were allocated to self employed people. The teachers rent rooms in the suburbs whose inhabitants are basically Christian with a rural background. More than 99% of them are still attached to their rural homes and belong to Christian church denominations, which include Catholic, Anglican, Methodist and Pentecostal Churches and many Apostolic groupings. The participant teachers (all male because there were no female teachers teaching chemistry at the school) are trained to teach at any high school in Zimbabwe (Corbin and Loving, 2000).

The school is an A-level institution, which offers the science curriculum to forms 1 and 2, integrated science to forms 3 and 4, with the A-stream classes (forms 3-1 and

4-1) taking physical science. Biology, chemistry, and physics are offered to A-level students. There are four junior laboratories for forms 1-4 and three senior laboratories for the A-level classes. The total enrolment for 2007 at the school was 2500 students, one of the largest in Harare. The research findings are relatable to all former Group B schools of Harare. Before independence in 1980, Zimbabwean schools were divided into group A for non-Africans and group B for Africans.

Research methodology

Teachers, students and members of the community were interviewed. Class observations were held and public gatherings such as church meetings were attended, to discuss with organizers (such as priests, pastors and church elders) of the different religious organizations in the community. The church leaders and the elderly were included because they influence the worldviews of the community in which the students live. The clergy would provide information on matters related to religion and the elderly would provide information on community culture.

The theme of this study demands a paradigm that uses naturalistic approaches to understand phenomena in context with natural settings. The qualitative research paradigm was chosen as it takes an interpretive, naturalistic approach to its subject matter, studying things/people in their natural settings, attempting to make sense out of phenomena in terms of the meanings that people bring to them (Langley, 1993; Denzin and Lincoln, 1994). Truth emerges as a complete picture of how different people think about the situation and about each other (Bogdan and Biklen, 1998). The researchers became immersed in the events around the participants in order to get insights from the context/environment in which the participants exist, the researchers becoming participants in the process, enabling them to get insights into how the students understand nature. The researchers gathered information on how teachers and students understand nature and chemistry, and also studied the community in which the participants lived, gaining insights into how school culture interacted with the culture of the community. Thus the interpretive inquiry was holistic, requiring participant observation, and taking place in natural settings (Lincoln and Guba, 1985). The danger of bias arising from a close relationship between researchers and participants as well as with the subject itself was constantly on the researchers' minds, hence they attempted to jealously guard interpretation and results against bias in order to bring out the bare truth (Bell, 1998; Cohen and Manion, 1994). Observation, collection, and analysis of the data led to a number of themes which would guide researchers on the next step to take during the research process (Davids and Hancock, 1998; Nyawaranda, 1999).

Sampling procedure

Sampling was purposive (as opposed to random), going for the rich sources of data. Thus participants were selected based on the potential they had for contributing to the project (Miles and Hubermann, 1984; Bogdan and Biklen, 1998). The four chemistry teachers at the school were included as participants. The school had two O-level chemistry streams with a total of 80 students. The students were asked to answer questions on how they viewed nature and chemistry. The responses were used to select twelve of the students as focus group participants based on how they impressed the researchers as having the potential to provide relevant information to the research problem. Two A-level chemistry students were also chosen, based on the recommendations of teachers who had taught them chemistry at O-level, in order to gain insight into how studying chemistry at O-level and extra maturity might affect

students' scientific worldviews. The goal of organizing target groups was to investigate concerns, experiences or attitudes/beliefs related to a clearly defined topic (Barnett, 2005). The majority of Christians in the community were members of the Catholic and Apostolic Faith Mission church denominations.

One pastor and a youth leader from each of the two church denominations were interviewed, as they would know about their members to a greater extent than anyone else. Their suitability to answer questions related to chemistry teaching was inferred from them having studied science at least up to O-level.

Four elder persons were also interviewed. One of them was chosen as he was an influential senior citizen who had lived and worked in the community as a civil servant. He is currently the School Development Association Chairperson. The other three elder persons of at least 50 years of age were chosen on the basis of their influence and reputation in the community. The four had each studied at least O-level chemistry and were literate enough to discuss the matters at hand.

Who and what to observe are determined by people and events perceived by the researcher to have meaningful and relevant information (Bogdan and Biklen, 1998). The researchers sought both teachers' and students' worldviews aiming at correlating data collected from the two parties. They also sought views of elder persons and community leaders with the aim to compare with the data from teachers and students. Questions put to the participants are listed in Appendices 1-4. Researchers disagree about the proper number of participants for a successful focus group (Barnett, 2005). Many researchers prefer a group ranging from 8-12 (Kitzinger and Barbour, 1999), 6-12 (Lindolf, 1998), 6-8 (Krueger and Casey, 2000), 5-6 (Green and Hart, 1999). The group should consist of 4-12 if the group is homogeneous and 6-12 if heterogeneous (Brown, 1999). Most researchers prefer a homogeneous group with the common threads being issues for discussion. To ensure homogeneity, form 3s were kept separate from form 4s. This also ensured that the participants would be comfortable talking to each other and could also consult researchers when it was necessary to do so (Willliams and Katz, 2001).

Gaining entry

Permission to carry out research was obtained from the Ministry of Education, Sport and Culture Head Office and from the other relevant authorities (Provincial Officers, District Officers), by visiting the officers with a letter of introduction issued by the University of Zimbabwe. The letter outlined the nature of the study and the kind of people who were expected to participate. Agreement was obtained from the school headmaster, teachers and students, and parental permission for the students to participate in the focus group was obtained. The clergymen, youth leaders and elders were also invited to take part in the study.

Teachers appeared uneasy meeting the researchers at a time the teachers were engaged in a go slow which took place almost throughout the whole of first term of 2007. It took persuasion for some of them to realize that the researchers were unconnected with the state security machinery. Students appeared to be enthusiastic about meeting the researchers at a time they were 'free' to roam the school as a result of the teachers' go slow. The problems characteristic of a researcher gaining acceptance into a community appeared to have cleared by the end of the two week period the researchers had budgeted for a familiarization period before data collection took place.

Reliability, validity and credibility

The issue of reliability and validity in qualitative research is embraced in the notion of trustworthiness, achieving results that are credible, transferable, dependable and confirmable (Lincoln and Guba, 1985). Credibility depends less on sample size than on richness of the information gathered and on the analytical abilities of the researcher. It can be enhanced through comparing data from various sources (Patton, 1990). Reliability and validity of findings were addressed through comparing data from different sources, persistent observation, leaving an audit trail, checking for representativeness of source of data, checking, and obtaining feedback from informants (Creswell, 1998; Miles and Hubermann, 1984).

Data collection techniques

Interviews and participant observation were used as data collection techniques. Students were asked to answer questions on paper and were observed as they intermingled freely with their colleagues. The researchers took notes as this progressed and interviewed the students individually, using the student's interview guide (Appendix 1). A-level students were interviewed following the same guidelines as for the other students. Teachers, pastors and elders were interviewed using the unstructured technique and followed by the focused interview technique (Appendices 2 and 3) in subsequent interviews. People's opinions on data and themes were sought during informal discussions with students and teachers on the school grounds, and with church goers at church meetings as checks on credibility, validity and reliability.

Personal interviews

Students, teachers, church leaders and elder persons were interviewed during February and March, 2007. Students and teachers provided the basis for the research. Church leaders and the elder persons provided data on the history and composition of the community. Students were interviewed on the assumption that students, as cultural beings, had particular experiences from their community (own culture), and as students, had particular knowledge acquired through science lessons. The researchers were seeking additional information to what had been gathered through general observations outside the classroom and lesson observation.

The researchers used interview guides (Appendices 1-3), and were free to probe and ask follow up questions, making use of the merits of personal interviews which include flexibility in the control of the interview situation, high response rate and the possibility of collecting supplementary information. The face-to-face interview is flexible and adaptable, hence useful when seeking in-depth information and perceptions (Babbie, 1993). Clarifications were sought through probing non-verbal cues such as facial expressions, gestures and hesitation. These non-verbal cues were reconciled with words to get insights into the real feelings and attitudes of the respondents. The semi-structured interview allowed depth to be obtained by providing the opportunity for the interviewer to probe and expand the interviewee's response and provide some kind of balance between the interviewer and the interviewee, thus providing room for negotiation, discussion and expansion of the interviewee's responses (Hitchcock and Hughes, 1989).

Students and teachers were interviewed in the laboratories, out in the open sun or in the shade of some trees depending on the situation on the day in question. The school is a double session school (hot sitting), hence office accommodation was

limited. The environment provided by the teachers' who were on go slow during the first part of the interview period did not negatively affect scheduled interview sessions, but augured well for informal discussions and observations with both teachers and students since nobody was under pressure of work. Students appeared to enjoy the situation and took advantage of the relaxed school setting, moving about almost freely. Interruptions were minimized during interviews, and each participant was allowed as much time as he/she required to respond to questions.

The interviews for those outside the school were mainly guided by what had emerged from the students' and teachers' interviews. Interviews of community leaders and pastors (Appendix 3) were a follow up to data related to the cultural biases of both teachers and students. Students were also interviewed in focus groups which comprised of groups (a) three form 3 girls, (b) three form 4 girls, (c) three form 3 boys, (d) three form 4 boys, and the two form 6 students (1 boy and 1 girl). These group interviews were done to establish the students' learning experiences both from the school and outside school as well as establish whether there were similarities between the school culture and the community cultures (Appendix 4).

Participant observation

Students and teachers were observed in order to establish how they related to one another and to the environment. This also helped researchers get a deeper understanding of the context in which events took place as well as enabled researchers to see things that participants might not be willing to divulge (Patton, 1990). One of the researchers became partly a participant and partly an observer. He participated by teaching some of the classes and observed by watching and analyzing the students' behaviour. The researchers also held informal discussions with students, teachers and members of the administration to compare the information obtained from interviews and observations with what people generally believed (Gabrielatos, 2004).

Lesson observation

Lesson observation was chosen as a technique for data collection because, as Romanowski (1998) put it, the manner in which teachers experience and understand the world plays a significant role in defining, selecting, and organizing information in their classroom. The way the teacher delivers the lesson reveals how the teacher himself/herself views the subject. The observation of the interaction between the teachers' scientific worldviews and the students' scientific worldviews would help establish their effects on the teaching and learning of chemistry. Lesson observation ascertained teacher preparation, lesson delivery and students' understanding of concepts, as well as gave insights into the normal classroom practices of the observed teachers.

The lessons to be observed were purposively sampled. Information obtained as a result of lesson observation, examination of the scheme books, and after-lesson discussions was compared with that collected during the teacher-interview discussions.

Each of the four teachers was observed giving a 40 minute chemistry lesson. Teacher Albert was observed teaching aromatic chemistry (form 4), teacher Benjamine, thermodynamics (form 4), teacher Chris, atomic theory (form 3), and teacher Dreamland, bonding (form 3). The topics happened to be taught at the time of the observation and they were all deemed suitable, as they all had the potential to include examples from culture. All classes were observed using an adapted Horizon Research, Inc. Classroom Observation Protocol which the authors have adopted in

their department and have found to be useful and appropriate for capturing meaningful learning. This protocol was consistent with the objectives of the study.

Data capturing

Descriptions of settings, people activities and situations, were recorded as field notes soon after the observations on the same day (Lofland and Lofland, 1984; Davids and Hancock, 1998). Full interview scripts were constructed from notes taken during interviews of teachers, students, community leaders and the elder people. Notes from lesson observations were also used as data captured. After-lesson discussions were held soon after the event so as to capture data whilst the memory was still very fresh. Problems associated with notes taking were minimized by capturing only what was deemed relevant. This also minimized sources of bias due to delay which might have led the interviewer to forget some of the details, particularly those which disagreed with the interviewer's expectations (Cohen and Manion, 1994).

Students' worldviews

Eleven of the twelve O-level students stated that chemistry is useful, practical and applicable to life at home; five of them believing that the subject is difficult, and four believing it to be not difficult. The other two were uncommitted. Eight of the students, including the one who was not committed to the notion of chemistry being useful, regarded the subject as necessary in preparations towards securing a place to study for medical degrees. Six of the students developed a liking for chemistry on their own, two students (1 male and 1 female) were inspired to study the subject by their parents. One student liked chemistry because of the influence of a doctor who saved her life.

Students believed that nature is beautiful, orderly, predictable, and can be understood through scientific studies. They also believed that there is need to conserve nature.

The O-level students do not find much relationship between western medicine and traditional medicine, although they are both processed from natural materials such as herbs.

The students belong to Christian religious denominations which have a strong bias against cultural medical practices in favour of western practices, as espoused by the teachings of religious leaders. They believe that spiritual powers are greater than science to the extent that some of them believe that some medicines will not have efficacy unless they are prayed for and that teachers and students should pray before lessons.

Two of the female students felt that house chores disturbed their studies, disadvantaging girls by comparison with male students, but a third one found solace in the expectation that the current female vice President of the country would tip the balance in the girl child's favour.

The two A-level students basically shared the same views as the O-level students on chemistry, medicine and religion except that the two A-level students exhibited greater maturity than the younger students.

Teachers' worldviews

The four teachers believed that chemistry is a powerful tool for explaining natural phenomena; a useful subject that makes life easier and interesting; and is the basis for the study of medicine**.** The teachers believed that nature is a god-given beauty which

mirrors god's powers and is above science. It is orderly, beautiful, difficult to understand, always changing and must be conserved. Three of them believed that there is no link between traditional medicine and western medicine, or between Christianity and traditional religion. One of the teachers was fanatical about Christianity and castigatory about African culture. He insisted on praying before lessons. The fourth teacher did not mix his spiritual views with his scientific views, practices the two separately, and does not use cultural views in his explanation of scientific principles in class. Two of the four teachers indicated that they respect for traditional culture.

Lesson observation results

The teachers observed were experienced, trained teachers, who also had experience of teaching under observation. They were aware of the researchers' intensions to observe their teaching and they, thus, anticipated what the researchers wanted to witness and they prepared accordingly. All the teachers used the problem solving technique. The science content was appropriate, and connections were appropriately made to other areas of study. Language and materials were appropriately used, and 'wait time' was appropriately applied to identify prior conceptions and misconceptions. Strategies and classroom management styles generally enhanced the quality of the lesson delivery, and there was evidence of active participation by students. Respect for student ideas, questions and contribution was also evident in all the classes. The general lesson climate was conducive, propositional and likely to influence students to move in the desired direction.

The only element evidently inappropriate in all the lessons was the minimal use of student enacted worldviews from their community. For example, when discussing the atomic theory a student asked "*what caused electrons to move away from the nucleus as atoms absorbed energy*". The teacher was at pains to explain and evidently failed to convince the student. The researchers felt that a simple example from everyday experience, involving people sitting around the fire, might have carried the day for the teacher. *"When the fire is small, people sit very close to the centre. As the fire gets bigger, the heat increases and people move away from the centre. …"*

All the teachers in the four observed lessons restricted most of their content to textbook material and did not include examples from what was available in the community. The community is very rich in examples which they could have used. For example, when teaching the structure of benzene, a sandwich could have been used to illustrate the shape of the molecule and the arrangement of the π-orbitals. The arrangement of s-orbitals in atoms could have been illustrated by cutting fruits of *Strychnos spinosa* plant (Shona: mutamba) of different sizes and placing the smaller shells into larger ones. The generally used practice of tethering a goat and allow it to graze could have been employed to illustrate distance of electrons from the nucleus. The larger the string, the larger the radius will be. When teaching aromatic chemistry, examples of sweet smelling plant exudates could have been used to illustrate the origin of the name aromatic. For thermodynamics, the practice of placing brewing containers such that temperature may be raised, for example placing containers in warm rooms to facilitate fermentation could have been used.

This failure to use students' enacted worldviews or examples from everyday use, was also evident to students as was revealed in the focus group discussions. Asked to comment on the failure to use students' enacted worldviews, all teachers lamented the heavy workloads they had, teaching large classes and racing against time to be able to finish the syllabus and prepare the students for exams. Thus the teachers tried to justify their practice of restricting themselves to using material from

previous lessons as prior knowledge.

However, that way they missed out on critical opportunities to build on student enacted worldviews. Nelson-Barber and Estrin (1995) pointed out that teaching methods that do not take into account students' enacted worldviews might confuse students, who might even feel denigrated by a system that appears to assume that they know nothing about science. Shumba (1999) also echoed the same sentiments. If the teachers put effort into including students' enacted worldviews in their teaching they would have chance to improvise teaching materials using locally available resources and likely develop methods to teach relevant chemistry as they might be better exposed to students' beliefs, values and norms. Such teachers would be better placed to teach chemistry in the context of the community of the students and thus improve on the relevance of the subject. Their students would be better prepared to integrate what they bring from their own culture with what they learn at school and be able to apply what they learn to solve problems both at home and at school, and thus aid towards the goals of the multicultural perspective in science education, as pointed out by Jegede and Aikenhead (1999).

Since the daily social experiences students have may contribute to inaccurate conceptions about the diverse scientific phenomena, inclusion of examples from students' enacted worldviews might address conceptual difficulties, as suggested by Ogunniyi (1988). The teachers also failed to take heed of Shumba's assertion (1999) that educators should make use of enacted worldviews emanating from the community to ensure that chemistry teaching does not only result in learning facts, procedures and techniques. Teachers should also help students develop scientific ways of looking at nature and scientific ways of looking at new problems. The failure by teachers to incorporate students' enacted worldviews in their lessons meant that they were missing out on chances to capitalize on opportunities for their students to engage on meaningful learning.

Views of church leaders

The church leaders claimed that they represented about 6000 people, most of whom were female. Thirty percent of the combined congregations were boys; forty per cent were girls; twenty per cent women; and ten per cent men. The community was generally poor. The church leaders expected science to "*recognize the importance of religion and link all developments to Christ*". Although the views of religion might not be directly linked to the teaching of O-level chemistry, they have an effect on the development of the student. Education at this level should be holistic. The total character of a person influences the way that person executes his/her duties/studies.

Their organizations gave courses on AIDS and disagreed with the use of condoms because they were not safe as "*they had pores which allowed viruses to pass through*". They taught that sex should be practiced by married people only and all sexual relationships should be open to conception. *"We do not agree with Non-Governmental Organizations who mislead people that even children have a right to have sex. Contraception is a sin. Natural family planning methods which make use of the 'safe period' must be used since artificial methods are risky to the woman."*

The Catholic Church allowed the use of herbs, but the Apostolic Faith Church forbade it. Both clergymen claimed to be able to pray for oil and render it curative. They both claimed that knowledge in science is a gift from God which should always be used in the praise of God. They said nature is abstract, beautiful, and more powerful than science, but can be dangerous and hostile. The spiritual world is more powerful than science.

The views of the two youth leaders, in general, agreed with those of the pastors in their respective churches. The religious views of the teachers and students could be traced to the clergy. Asked to comment on the claims by some students that all medicines needed to be prayed over to improve on efficacy, the church leaders concurred that God's powers were so immense that the human mind could not measure up.

Views of the elders

The elders agreed with the clergymen on religious matters but disagreed on cultural matters. The elders found nothing wrong on consulting spirit mediums and using herbs. Their decisions on the choice of western or traditional medicine depended on how they viewed the cause of the particular health problem. They claimed that some problems required traditional solutions and others needed western solutions. They said that traditional educational systems, which all children should go through, required children to be well versed on cultural matters. The congregations that all children attend required children to know about western religious views. Teachers should, thus, be prepared to interact with students who had knowledge of both traditional and western systems.

All clergy and elders agreed that TV was destroying religion and the cultural lives of the community. They found no relationship between chemistry education and church attendance, although there might be a relationship between chemistry and medicine in general since all drugs emanate from chemistry. The elders look forward to having an 'up-market' community which is educated. They said that chemistry should be taught so that it lifts up the life of the community. No subject would ever be a threat to either religion or culture, and they found nothing wrong about praying before lessons although there should be respect for the different religions represented in the classes. In line with African traditional and religious values (Akpotu, 2005; Akpotu et al., 2007), the elders did not condone the use of contraceptives, but instead, vouched for the use of the "safe period." Thus, the effect of religious personnel and the cultural beliefs on the worldviews of students was very pronounced. Some students appear to be very seriously affected by the views held in their environment. Teachers need to be aware of what goes on in the communities from which their students come. That way they might be able to deal with the students' misconceptions that emanate from views of the community which may not be congruent with school science. Ignoring the community might not be in the best interest of the students. However, senior students might be able to distinguish the appropriate from the inappropriate. But even adults are known to have misconceptions which emanate from traditional education or equivalent systems (Baranowski et al., 2007; Taber, 2003).

Data analysis

Data was broken down into simpler and manageable units, according to Brown (1996) and Duffee and Aikenhead (1992), and placed into logical and meaningful categories so that it could be examined in a holistic manner. Thus, each script and interview excerpts was recorded, typed up, and analyzed, given meaning and categorized to establish patterns and trends in order to come up with concepts and hypotheses. Categorization was also made in relation to male and female students to establish possible differences that might exist and come up with themes. Data analysis and interpretation was on going, taking place from the data collection stage and carried out throughout the whole research process (Bogdan and Biklen, 1998).

Data collected through personal interviews was transcribed and this involved the production of a written version of the interview (Davids and Hancock, 1998). This was done by looking at interview notes (field notes) and re-writing them soon after the interview when the memory was still fresh. Identifying and naming the conceptual categories into which phenomena observed were grouped. This created the framework for analysis. Scientific worldviews (ideas) that appeared to be similar were grouped together. Themes emerging from raw data were the prime aim. This is sometimes referred to as 'open coding'. This was achieved through reading each transcript, highlighting each item of data seen to contain relevant information, thus, recording the whole interview as an excerpt (the written script and the face-to-face talk). The excerpts were then read through and grouped into categories. The categories were then compared to give rise to themes, forming the basis of interpretation, giving meaning to analyzed data, identifying themes or hypotheses. The categorization and careful examination of categories to determine how they are linked is a complex process and is called 'axial coding' (Strauss and Corbin, 1990).

Two criteria were used to establish the differences between the teachers' and the students' scientific worldviews: the way they viewed traditional medicine and the way they viewed nature and chemistry. This was triangulation of data to ensure validity and reliability of results. The way the teachers and students viewed nature, traditional medicine, and chemistry came out of the interviews and also depended heavily on the interpretation of the verbal and non-verbal expressions of the interviewees by interviewers.

Matching teachers' and students' scientific worldviews

This task was developed to show how some teachers may be potentially more effective than others at helping students cross cultural borders. The cross-culture pedagogical paradigm for teaching science may be encouraged in order to avoid cultural conflicts (Jegede and Aikenhead, 1999). Teachers were coded and matched with students based on the way both viewed traditional medicine and nature.

Some teachers and some students preferred western medicines to traditional medicines, some of them viewing traditional medicines as being heavily dependent on chemistry. One student and one teacher believed that the dosages used in traditional medicine were not proper. Most participants (teachers as well as students) viewed nature differently but agreed on some aspects such as God created nature and nature is beautiful. Table 1 revealed the emergence of themes and patterns: the relationships between teachers' and students' worldviews and the relationship between boys' and girls' worldviews. Boys tended to have mixed views which were influenced by both religion and culture whilst girls tended to be more influenced by the Christian religion. Some teachers and some students did not appear to realize the chemical relationships between western medicine and traditional medicine and this appeared to be resulting from the influence of their cultural and religious beliefs because churches tended to enculturate them towards western values. Table 1 revealed that 50% of the students shared similar views with teacher C, whilst 25% agreed with teacher B, 8% agreed with teacher A, none agreed with teacher D and 17% did not agree with any of the teachers. The inference has serious implications for cultural cross-border negotiations in science teaching and learning at this particular school. Whilst teacher C could potentially help 50% of the students cross cultural boundaries between the students' worldviews and the school culture, he is likely to be helpless to the other 50% and teachers B and A might help 25% and 8% of the students, respectively. There are 17% of the students without even a teacher at the

school to help them cross the cultural boundaries. There is also the case of teacher D who is potentially helpless at the school as far as helping students cross cultural boundaries is concerned. Thus, generally, except for teacher C, the findings reveal that the teachers were not integrating students' enacted scientific worldviews into their teaching of chemistry. Teachers should always take indigenous or prior knowledge of students into consideration when teaching (Aikenhead and Jegede, 2000).

Table 1. Matching teachers' and students' scientific worldviews using traditional medicine and nature

Student	Gender	A	B	C	D	E
Bryant	M		x			
Braga	M			x		
Dowela	F		x			
Fatsota	F					x
Gibson	M					x
Memory	F	x				
Pitiri	M			x		
Piridzayi	F			x		
Pirirai	F		x			
Shikila	F			x		
Tafirenyika	M			x		
Tawonera	M			x		
Totals	12	1	3	6	0	2
%	100	8	25	50	0	17

Key: E= Not matching with any of the teachers.
Pseudonames have been used.

Table 2. Matching teachers' and students' scientific worldviews on how they viewed chemistry

Student	Gender	A	B	C	D	E
Bryant	M	*				
Braga	M			*		
Dowela	F			*		
Fatsota	F					*
Gibson	M			*		
Memory	F			*		
Pitiri	M				*	
Piridzayi	F			*		
Pirirai	F		*			
Shikila	F		*			
Tafirenyika	M			*		
Tawonera	M			*		
Totals	12	1	2	7	1	1
%	100	8	17	59	8	8

Key: E= Not matching with any of the teachers.

Similar themes and patterns were established using a criterion based on teachers' and students' worldviews on how they view chemistry (Table 2). This was done as a check on the above results. It became obvious that teachers and students viewed science and nature differently and that teachers needed to be very careful if they were to assist students in border-crossing between students' enacted worldviews and school science. The majority of the students agreed with the teacher coded C. This

teacher's views on Christianity were comparable with his views on science and his traditional beliefs accommodated science. Some of the students subscribe to similar views. This teacher may have studied the culture of the community or he may inherently share the same culture as the community he is living in. He is thus positioned to practice cross-cultural teaching (Aikenhead and Jegede, 2000; Corbin and Loving, 2000). The enacted worldviews of most of the other teachers are generally not compatible with the enacted worldviews of most of the students (Table 2) as they do not appear to respect African culture, hence they only agree with 33% of the students and 8% of the students do not have any of the teachers on their side. The conclusion arrived at using the criterion: the way teachers and students viewed traditional medicine and nature are vindicated by the conclusion arrived at using the criterion based on teachers' and students' scientific worldviews on how they viewed chemistry.

Church leaders were interviewed to compare their views with the views of teachers and students. There was a general agreement between the church leaders on what they perceived as science and what they perceived as nature from the churches' point of view. They view science from the social point of view and blame science for enabling students to watch sinful programs on television, suggesting that the media culture was interfering with church culture. They generally agreed with teachers and students who attend their respective churches, revealing that the church influence was evident in both teachers' and students' scientific worldviews. Whereas most teachers and the church leaders and most students agreed on spiritual matters, they differed on the use of traditional medicines. Catholics were more accommodating but the African Faith Ministries rejected traditional medicine. Notwithstanding, the church had a profound impact on the way students viewed the criteria which were studied.

Views from focus group discussions were compared with views that emerged from interviews of individual students. Some students pointed out that teachers were not giving students chance to perform experiments because the teachers were lazy. They argued that the teachers' excuses about lack of facilities were futile since appropriate experiments could be performed using natural materials which were readily available and abundant. For example, village people use different fruits to prepare beverages. Such practices could be used when teaching fermentation and in the study of alcohols. If the teachers successfully integrated students' enacted scientific worldviews with their own, they would take their past experiences into consideration and enhance the sharing of experiences with students and ultimately enrich their own enacted scientific worldviews and enhance their chances to assist students negotiate border crossing. One student burst out: *"teachers are unable to explain simple concepts and confuse us by explaining those concepts found at higher levels. Why do they not simply use examples which we are familiar with?"*

Thus, even some students realize that teachers fail to assist them negotiate cultural borders. Some students claimed that teachers do not use simple language and as a result when they ask questions students do not respond because they would not have understood the ideas. The focus group discussion did not only confirm findings which had emerged from interviews with individual students as had been planned; it also brought out data that had eluded participants at the individual interviews stage, and further vindicated the known fact that the way the teacher views the world affects the way he/she teaches. It also emerged that as teachers focused on the syllabi, they failed to use real life examples, further exacerbating the difficulties students experienced in the learning of science at the school. Home and real life examples incorporating science in the community to school science would help the students

remember what they are taught. The focus group discussion further revealed the influence of family and community peer groups on the enacted worldviews of students as they talked about advice from parents, relatives and former students of the particular school, further revealing that the teachers do not consider experiences pupils bring from their community and during the after observation discussions, the teachers acknowledged restricting themselves to textbook information.

As a result, scientific worldviews of teachers were running parallel to students' scientific worldviews and this would not augur well for smooth cross-border crossing. The western scientific perspective may harmonize with the teacher's enacted worldview (Cobern, 2000) but the students enacted worldview in the non-industrialized third world countries likely do not harmonize with the western worldview (Aikenhead, 1997). Hence school science would be foreign to the student and integration of school science with the students' enacted science would appear like cultural imperialism/colonialism (Bapttiste and Barman, 1995).

Conclusion

The worldviews which the teachers and students brought to the classroom were largely related to religion and the way of life of the community the teachers and students come from. These do not appear to have much direct bearing on the teaching and learning of chemistry at O-level, but they have influence on how the whole person is shaped and that is an important factor in education. The teachers need to incorporate the science that is practiced in the community into the way they teach chemistry so as to influence the way the students view chemistry and help the students appreciate values of chemistry beyond its use as a vehicle to "enter medical school."

The different religious inclinations teachers and students have might have a bearing on the types of examples teachers may choose to illustrate concepts, for example cooking and beer brewing. These will not militate against the chemistry taught and how it is taught, although a teacher who is inclined against beer, due to his/her religious teachings, might be against using beer-brewing to illustrate fermentation, an important component of industry.

The gaps between students' enacted worldviews and school culture was large because teachers behaved as if students did not have enacted worldviews. They admitted, after lesson observations, that they did not take cultural knowledge into account when teaching. This failure by teachers to make use of opportunities to assist students cross cultural borders might lead students to practice rote learning as pointed out by Ausubel (1968), West and Fensham (1974) and Novak (1977, 2002). Focus group discussions revealed that students were aware that there were borders to cross, hence the exclamation by one of them that teachers do not use common explanations.

Comments by the two A-level students indicated that students at this school develop as might be expected by their community, as revealed by Jona when he says that he is now able to choose between the appropriate and the inappropriate. He is capable of choosing traditional rituals when the situation demands and to choose Christianity when he thinks that it is proper. This duality of religious adherence might seem odd to non-Africans, but it is quite common in African circles to practice traditional religion and Christianity at the same time.

From the interviews it appears that cultural beliefs and religion would influence life in the classrooms at this school. However, events of the lesson observations and subsequent after lesson interviews, suggest otherwise since the teachers do not refer

to home-based prior knowledge, effectively meaning that culture brokering does not take place at this school. Thus critical opportunities to build on or draw from students' existing community knowledge are, thus, missed. Identification and correction of misconceptions emanating from students enacted worldviews will be easier if the teacher understands how the misconceptions arise. Teachers should help students realize that chemistry learning does not require divine intervention. They should correct students' misconceptions and engage students in meaningful learning. Teachers should use their culture brokering skills to assist students cross cultural borders between their community's culture (in this case, a culture dominated by religion and traditional knowledge) and the culture of school science.

The Curriculum Development Unit should insist on teachers using students' enacted worldviews and use examples close to the daily experiences of students. This would assist students move between their everyday life-world and the world of school science as well as influence how they deal with cognitive conflicts between those two worlds.

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Appendix 1
Questions to students
Name of student:
Form:

1. What is your religion?
2. What does your religion say about traditional medicines?
3. Do you use traditional medicines at home?
4. What is the relationship between traditional medicines, chemistry, and the medicines used at the clinics?
5. What are your feelings about chemistry?
6. Is chemistry a difficult subject to study?
7. What is the value of studying chemistry?
8. Are there any dangers associated with studying chemistry?
9. When you are at home, how do you use the knowledge you get from chemistry lessons?
10. What do your parents do to encourage you to study chemistry?
11. What aspects of chemistry learning do you enjoy most?
12. What does your teacher do that helps you find a relationship between the chemistry you learn at school and the chemistry you come across at home?
13. What is the relationship between chemistry, nature, and religion?
14. Which of them is the more powerful?
15. What are your views about the beauty of nature?
16. What are your religious views about traditional medicines?
17. Can you tell me whether nature is predictable and if it can be explored?
18. What does your religion say about nature and chemistry

Appendix 2
Questions to teachers
Name of teacher:
Qualification:
Period at this school:

1. What training have you had to be able to teach at this school?
2. If you were to start all over again, would you choose to be a teacher?
3. What do you like most about teaching chemistry?
4. Are there any aspects of chemistry that you do not enjoy teaching?
5. What discussions about worldviews do you recall in your career?
6. How do you establish your students' enacted worldviews?
7. How useful are your students' worldviews to your teaching of chemistry?
8. How do you reconcile your students' worldviews with your own worldviews?
9. What can the school do to help you make more effective use of your students' world-views when teaching chemistry?
10. How do you think the ministry could help the situation?
11. How does a prayer before a lesson help in the study of chemistry?
12. How do students whose religion differs from the teacher's respond to prayer before lesson?
13. What are your views about those who consider chemistry a dangerous subject?
14. What is the relationship between chemistry nature, and religion?
15. What do you do to ensure that your students view chemistry as a useful subject?
16. How do you establish whether your students understand the relationship between traditional medicine and chemistry?
17. What are your religious views pertaining to the use of traditional medicines?
18. What are your views about the predictability and explorability of nature?
19. How do you view the relationship between chemistry and nature?
20. Which one is more powerful than the other?
21. What does your religion say about nature and chemistry?

Appendix 3.
Questions asked to clergymen and elders.
Name of Elder/Clergymen:
Qualification:
Organization:
Period in Community:

1. What is the composition of the community around this school?
2. Does TV have any influence on religion and culture?
3. Does knowledge of chemistry have influence on the use of herbal medicines?
4. What is the effect of learning chemistry on church observances such as church attendance?
5. Do you encourage students to study chemistry?
6. Do you have any prominent chemists from this school?
7. Do you have any prominent Chemist who once studied at this school?
8. Describe the religious composition of this community.
9. Describe the culture of the community.
10. What is the relationship between chemistry and traditional medicine?What is the relationship between traditional medicines and medicines used in clinics?
11. What are your ideas about the chemistry taught at this school and its use to the community?
12. Do you think that the teachers who teach chemistry at this school know what the people of the community believe about traditional medicine?
13. What chemistry beliefs of the community could be discussed in chemistry classes?
14. What are the relationships between chemistry and culture in the suburbs that provide students to this school?
15. Do you think that students should consider culture and religion to be in control of everything else in life?
16. What are your ideas about some students who believe that drugs (including herbs) require prayer for efficacy?
17. Do you think that chemistry education is a threat to your religion or culture?
18. What should be done to make sure that chemistry learning, religion and culture co-exist?
19. What influence do you think culture and religion have on the way students learn chemistry?
20. Would you encourage teachers and students to pray before lessons?
21. If you allow them to pray before lessons, what are you going to do for, for example, non-Christians?

Appendix 4
Focus group interview guide

1. What chemistry would a person from your suburb who never learnt chemistry at school be able to use and teach to others?
2. What other chemistry is practiced both at home and at school?
3. How do your teachers help you to relate the chemistry learnt at school and the chemistry practiced at home?
4. What do you think your teachers should do to help you understand chemistry?
5. What chemistry do you talk about at church?
6. Does your religion contribute to your study of chemistry?
7. What do you think your religion should do or should not do to help you study chemistry better?
8. How do you think a traditional healer would benefit from studying chemistry?
9. How can a housewife benefit from studying chemistry?
10. What can teachers, pastors, and parents do to harmonize religious views, cultural views, and school authorities' views about chemistry?