Exploring the use of indigenous knowledge and technology in the teaching of waves and sound in grade 10 physical science

Khwinana Lesiba
University of Limpopo
lesik@webmail.co.za

This study explores the opportunities and obstacles of an integrated approach to teaching of science and indigenous knowledge and technology (IKT), as advocated in the new South African curriculum for the Natural Sciences. The topic of ‘sound and waves’ is introduced through an exploration of IKT: African drums, thumb piano and Kudu horn. The sample consisted of thirty grade 10 learners who studied physical science as one of their curriculum subjects. Data was obtained from post questionnaires administered to learners at the end of four series of lessons conducted, including those of two science teachers who attended these lessons as neutral, outside observers. Among the observed positive aspects of using IKT is an active participation in lessons and a high level of interest among learners. The results obtained seem to show that all the learners knew about the three traditional instruments used from their community before the instruments could be used in this study. Through the use of the three instruments, learners were able to define, associate and apply a high level of understanding sound and waves concepts. Learners also demonstrated enthusiasm, interest and motivation. As for teachers, in particular, they felt that the integration if IKT can foster interest, understanding and increased motivation on learners.

Introduction

African Indigenous Knowledge and Technology received no recognition in Western-European rule in Africa, particularly South Africa due to apartheid. The Western dominance relegated the African Indigenous Knowledge and Technologies to the level of non-existence, and inhibited its development. According to Vilakazi, in Seepe (1998:70), educated Africans were educated as part of Western civilization, but unlike their Western counterparts, they were placed in a suffocating status of not being able to engage themselves in developing a civilization of which they felt a part. Yet Africans had their way of doing things from the beginning of time. The national curriculum statement grade 10-12 (general) points out that now people recognize the wide diversity of knowledge systems through which people make sense of and attach meaning to the world in which they live. The term ‘Indigenous Knowledge Systems’ in the South African context refers to a body of knowledge embedded in the African philosophical thinking and social practices, that has evolved over thousands of years (Department of Education, 2003: 14). Higgs and Smith (2002: 100) point out that there is, however, another perspective in contemporary debates on the nature of African Philosophy that is opposed to this notion of Western dominance. Africa’s scientific and technological sophistication prior to European setting on the continent is part of the lost Africa (Le Grange, 2000, 114). There is therefore a need to develop knowledge and understanding based the contributions made by Africans, particularly in Science teaching and learning. Importantly, the education transformation in South Africa has dawned a new curriculum, an outcomes-based-oriented Curriculum 2005 (Gumbo, 2003: 114).

This study attempts to explore the integration of indigenous knowledge and technology instruments, which is part of the Indigenous Knowledge Systems (IKS) into the Mainstream Science as described in the present science syllabus. This is a challenge to all science teachers in that the present teaching and learning materials include none or very few topics from indigenous knowledge and technology.
The Purpose and research questions of this study

The aim of this study is based on the exploration of the use of Indigenous Knowledge and Technology materials in the teaching of science (sound and waves).

The following aim was considered as relevant to this study:
- To measure to what extent the traditional indigenous materials/instruments can be useful in teaching sound and waves in grade 10 physical science.

The study attempted to answer the following research questions:
1. Do learners have pre-knowledge sufficiently enough to be used in science teaching and learning?
2. Can learners relate the relationship between energy and sound produced by a vibrating drumhead?
3. Can learners understand the concept of amplitude and how it determines the softness and loudness of sound?
4. Can learners understand the concepts of frequency and pitch and relate these concepts to why the strings of dipela produce different sounds?
5. To what extent can learners use lepatata to explain sound and waves concepts?
6. Do learners appreciate the use of traditional instruments in teaching and learning sound and waves?
7. Do science teachers appreciate the use of traditional instruments in teaching and learning sound and waves?

The study may be of assistance among others to learners. This will be attained among others when learners understand and apply the concepts of frequency and pitch and be in a position to relate the concepts to why the strings of dipela produce different sounds. This will be answered by research question number 6 of this study.

Literature review

This study is informed by, first Multicultural Science Education, which is according to Bennet (1990: 11) an approach to teaching and learning that is based upon democratic values and beliefs, and seeks to foster cultural pluralism with culturally diverse societies and an independent world. Second is Science-Technology-Society (STS) approach). Third, is constructivism, a theory in which scientific content knowledge, how it is constructed and how an individual learner constructs it in the classroom based on cultural diversity of the learners. Fourth is practical work which according to Dekkers (2004:19) refers to activities in the science classroom in which learners observe and interpret events or phenomena occurring to objects, guided by the teacher and the teaching materials. Learners will be able to make sense of their social environment, artificially constructed environment and natural environment, as advocated Solomon and Aikenhead (1994).

Definition of concepts/term used in the study

The following definitions are adopted as being central to this study:
- Indigenous Knowledge and Indigenous Technology.

-Indigenous:
When applied to populations this term refers to the original inhabitants of an area which has subsequently been occupied by migrants (Seymour-smith, 1990:149).

-Technology:
Bosch (2000:10) defines technology as the use of knowledge, skills and resources to meet human needs and wants and to recognize and solve problems by investigating, designing, developing and evaluating products and systems. Indigenous knowledge and technology, for the purpose of this study, therefore, refers to the knowledge and technology of Blacks as the original inhabitants of South Africa, which has subsequently been dominated and suppressed by the Whites’ colonial and apartheid rule. It becomes clear now that indigenous knowledge means the knowledge that indigenous people possess (Gumbo, 2003:16).

To put this study in the correct perspective, the Sepedi words are hereby also defined as well as the definitions as provided by Kruil (1994) including Prinsloo and Sathekge (1996).

- **Dipela/thumb piano**
  A thumb piano is a keyboard musical instrument in which sound is produced by plucking the strings with fingers. The strings are tightly stretched metals, which are mounted to the frame/hollow gourd/case. The strings vibrate and therefore produce sound.

- **Traditional instruments**
  For the purpose of this study the traditional instruments are those made by South African Blacks and developed by themselves in contrast to those developed by the Whites. Only three of them are referred to in this study, namely the drum, thumb piano and the Kudu horn.

**Methodology**

In this research endeavour, the researcher used qualitative research design in which qualitative data was obtained. Within this paradigm, the researcher embarked on a case study strategy which pertains to the fact that only a limited number of units of analysis (often only one) such as individuals, or group or an institution are studied intensively (Welman and Kruger, 2001:183). The study also used action research in which the researcher aimed at improving the practice of science teaching in the classroom by integrating the indigenous instruments and evaluate on how to improve the researcher’ own practice. Action research as supported by Berlin (1997:78), is integral to both the improvement of educational practice and of teaching.

This study used questionnaires with open-ended questions because at one end of the range, qualitative data collection instruments may begin to resemble quantitative ones (Punch, 2000:57). All the instruments used for the purpose of this study were developed and administered by the researcher because the researcher is seen as the primary instrument for data collection. For example: A questionnaire (Appendix A) was used as an interview schedule administered to elders (table 1). The aim of the interview was to obtain information about *meropa*, *dipela* and *lepatata* (among others on how they are made) which was later used in the classroom. Appendix A was also administered to the learners as a diagnostic test to determine whether they know about the traditional instruments at beginning of lesson 1.

At the end of lesson 3, an individual questionnaire (Appendix D), was given to learners to complete at home. The aim of this questionnaire was to determine whether learners understand the concept frequency and pitch of sound and whether learners can relate these two concepts to why the strings of *dipela* produce different sounds. Appendix E, also an individual questionnaire, was administered to learners at the end of lesson 4. The aim of this questionnaire was to determine whether learners can apply the scientific concepts, for an example frequency, amplitude, etc. on how the Kudu horn produces sound. An additional questionnaire (Appendix F) was administered to learners at the end of every lesson presented. Learners had to provide their own views about the use of the traditional instruments. Table 4 provides learners’ responses to appendix F.
A separate questionnaire, (appendix G), was used by the two science teachers at the end of every lesson presented. In using appendix G, the two teachers had to assess how the traditional instruments were used in the teaching of sound and waves concepts. Table 8 summarizes the teachers’ responses to appendix G. An unstructured interview based on appendix G, was held with the two science teachers who attended the lessons used for data collection at the end of the four series of lessons presented.

In addition to interviews and questionnaires used in this study, data was also augmented with a personal journal. The aim was to report on all the deliberations of the study (actions, views, activities, successes, failures, etc.). In obtaining data, the researcher maintained that honesty, trust, friendship prevail among all the participants in this study. Learners and teachers’ confidentiality and anonymity was also guaranteed. Attendance by learners was compulsory and only the completion of questionnaires was voluntary.

The study sample

The study sample is from a rural school in the Bakenberg district of the Limpopo Province. The target group consisted of 30 grade 10 learners, 13 males and 17 females studying physical science. Grade 10 was chosen because its curriculum contains sound and waves as topics.

The pilot study

For the purpose of this study, piloting of the lesson activities and instruments was done at a nearby secondary school to a group of grade 10 learners also studying physical science as one of their curriculum subject. Ideally, piloting should be send to people who are similar to the selected sample (Bell, 2001: 132). Permission to pilot the lesson activities and instruments was granted by the School Governing Body and the School Management Team of the school.

Instruments

To obtain data about traditional instruments, the researcher spent time with the elders as an observer when the traditional instrument (meropa, dipela and lepatata) were made, importance to culture, etc.

Validation and reliability:
- Relevance of the indigenous instruments
  The materials used were chosen in accordance with the grade 10 syllabus (in secondary schools) on sound and waves because sound is a wave motion.

Mechanically recorded data.
  Photographs were taken by the researcher in carrying out this study. The photographs include those of elders making use of traditional instruments in concerts and festivals, the learners making use of the traditional instruments in a science classroom to learn science, and the learners making use the traditional instruments in the school milieu to entertain themselves.

Data analysis

Data analysis of the responses to open-ended questions in questionnaires was done in three phases. The learners’ responses were grouped according to the questionnaires (Appendix A-F). Learners’ responses in a given questionnaire were then grouped together according to questions into the following categories: correct; semi-correct and totally wrong responses. Subsequently the researcher was able to categorize the learners’ written responses. Each individual questionnaire was then placed in an appropriate category. The
response rate was calculated out 30 learners because all the learners submitted their individual questionnaires in all the four series of lessons conducted. In addition to the above the researcher also analyzed a personal journal and photographs taken during the entire study.

**Results**

The results of this study are presented in four phases that constitute the core of the study, namely:

- Exploratory phase (Appendix A).
- Design
- Implementation
  This phase has the following subsections based on sound and waves concepts: introduction (Appendix B), understanding (Appendix C), definition (Appendix D – question 1), and application (Appendix D – question 2 and E).
- Evaluation
  This phase has the following subsections: learners’ views about traditional instruments (Appendix F), and teachers’ views about traditional instruments (Appendix G).

*The exploration phase*

As was expected and based on the theoretical framework of this study, the researcher found constructivism most befitting in this phase, on the grounds that learners build their own knowledge and experience in relation to their prior knowledge and experiences. Learners’ responses to appendix A are given in table 2 below:

**Table 2. Response of learners to appendix A**

<table>
<thead>
<tr>
<th>Name of instrument</th>
<th>Where seen?</th>
<th>Ever played?</th>
<th>Significance to culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepatata</td>
<td>Moketeng</td>
<td>No</td>
<td>• Le hlabo mokgoši</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Entertainment</td>
</tr>
</tbody>
</table>

The overall impression from table 2, which answers research question number 1 of this study, is that learners have pre-knowledge obtained from the community (e.g. elders), which is sufficient enough to be used in science teaching.

*The concepts introduction phase*

93% of the learners realized that for the membrane of the drum to vibrate, it needs energy, and the vibration causes the rice on top of the membrane to move up and down.

*The concept(s) understanding*

**Table 4: Appendix C. Learners’ responses to the concept amplitude and how it determines the softness and loudness of sound.**

<table>
<thead>
<tr>
<th>Category</th>
<th>Q. 1</th>
<th>Q. 2</th>
<th>Q. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct answer</td>
<td>87</td>
<td>87</td>
<td>45</td>
</tr>
<tr>
<td>Semi correct answer</td>
<td>10</td>
<td>13</td>
<td>44</td>
</tr>
<tr>
<td>Totally wrong answer</td>
<td>3</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>
For the purpose of answering research question number 3 of this study, appendix C was administered. Learners were expected to use the concepts amplitude to identify a loud and a soft sound, from two diagrams of transverse wave, one with a higher amplitude and the other with a shorter amplitude but all having the same wavelength. 87% of the learners answered question 1 correctly, and 3% provided wrong answers whereas 10% provided semi-correct answer.

The understanding phase is also summarized in tables 5 and 6, i.e. appendix D and E respectively. For both appendix D and E the following categories of concept levels were applied, example:

- **definition**: learners use definitive aspects/ attributes of the word in an accepted scientific sense.
- **associative**: learners associate the given word to an object or event in his/ her everyday life.

100% of the learners were able to define frequency and pitch (question 1). 88% of the learners seemed to have developed the ideas of frequency and pitch from the ruler model and managed to associate the two concepts to *dipela* (question 2).

In response to question 1, L.D mentioned that:

“frequency is the number of movements the ruler made in moving up and down in one second.”

The Kudu horn lesson was the last and the summarizing lesson in which learners were expected to apply what they learned in the previous three lessons. Table 6 provides the responses as to how the learners performed with regard appendix E (question 3 – Using the Kudu horn to explain sound and waves concepts).

**Evaluation**

*Learners’ views about the use of traditional instruments*

The learners’ views about the use of traditional instruments in teaching science provide responses to appendix F and the learners’ views answer research question number 6 of this study. 100% of the learners mentioned the traditional instruments were attractive and that they liked lessons in which the three traditional instruments were used as teaching and learning aids.

B.W: “I like about the strings of thumb piano are not equal so it can vibrate different sounds. If the strings are equal it will produce same sound.”

63% of the learners were able to come up with some advantages of teaching science using traditional instruments. Furthermore learners mentioned that the traditional instruments helped them to understand some of the concepts like energy, vibration, amplitude, frequency, pitch and wavelength.

M.Z: “It helped me to understand the frequency because the shorter string makes a higher frequency and longer string makes a lower frequency.”

*Teachers’ views about the traditional instruments*

The teachers’ views about the use of traditional instruments in the teaching of sound and waves answers research question number 7 of this study.

Traditional instruments were played most frequently than these days. I went through secondary school science, even went to the College of Education, but never thought that the traditional instruments can be of great help in facilitating the understanding of the science concepts (Matsobane, journal, May 2, p.3).

**Journal**

The researcher described and recorded what the elders did and said when they were constructing the traditional instruments. The recording also included what the researcher observed when the elders were using the traditional instruments, including the classroom activities. Recording in the case of both learners and elders included descriptions of events, incidents and issues of both individual and group activities.
Discussion and conclusion of the study

The objective of the present study was to explore the opportunities and obstacles of an integrated approach to teaching of science and indigenous knowledge and technology (IKT). The study was conducted at a secondary school in a grade 10 class. The results obtained were used to answer the research questions of the study. The majority of learners’ responses are in line with the debates and previous studies carried out around the integration of indigenous knowledge and technology with the mainstream science. Among the literature display works are those undertaken by Seepe (1998), the Department of Education (2003), Le Grange (2000), Higgs and Smith (2000), Reiss (2000) and Gumbo (2003).

The first research question addressed the issue of whether learners bring what they learned in their community to school. The outcome showed that learners bring to school what they gained from their community when they come to school. 100% of the learners knew about the traditional instruments used for the purpose of this study. The second research question addressed whether the learners can come up with the relationship between the amplitude and the sound produced by vibrating drumhead. 93% of the learners realized that for the membrane of the drum to vibrate, it needs energy, and that the vibration causes the rice on top of the drumhead to move up and down. Learners understood that the movement of rice differs when beating softly as opposed to hard, and the responses answers research question number 3 of this study.

It follows from table 5, which answers research question number 4, that learners were able to define and associate the concepts. Only 12% of the learners were unable to associate the concepts of frequency and pitch to how the strings of dipela produce different sounds. 40% of the learners, only identified kinetic energy and sound energy, and failed to realize that the chemical energy in a person, who is playing dipela, makes it possible for the player to pluck the strings. The overall impression from table 6 is that learners were able to apply and associate the sound and waves concepts on how the Kudu horn produces sound. For example, 77% were able to apply and associate the wavelength as compared to vibration (100%). The majority of the learners mentioned that the traditional instruments used for the purpose of this study helped them to comprehend the sound and waves concepts, and teachers shared the same sentiments as learners. Both learners and teachers’ responses answer research question number 6 and 7, respectively.

It is without doubt that the use of traditional instruments can support and facilitate the constructivist approach to learning and teaching. From this study, it is clear that the traditional instruments can be regarded as a neglected aspect in teaching of science. This shortcoming in the teaching of science may be a fundamental reason why learners find sound and waves concepts difficult to understand. It is therefore recommended that the use of traditional instruments be incorporated in the teaching of science. One way of doing this would be the use of science and IKT simultaneously or interchangeably.