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# The influence of local worldview presuppositions on learners' conceptions of Selected Mechanics topics

**Cynthia Fakudze**
School of Science and Mathematics Education, Faculty of Education, University of the Western Cape, Bellville, South Africa
cfakudze@uwc.ac.za

The study is situated within a worldview theory as espoused by socio-cultural constructivists. Science classrooms in secondary schools in Swaziland are culturally largely homogeneous where learners and their teachers have a strong grounding in traditional Swazi culture. The aim of this study was to investigate whether the conceptions held by Grade 11 learners of selected mechanics topics were influenced by the worldview presuppositions prevalent in their socio-cultural environment. The learners were exposed to a socio-culturally-based teaching/learning strategy that integrated selected indigenous knowledge presuppositions into school science. The learners were given a pre-and post-physics achievement test (PAT). At the end of the intervention, a focus group interview was conducted with some of the learners. Data on selected PAT questions were analysed quantitatively and qualitatively. The learners' responses to the focus group interview and the PAT's open-ended questions were analysed at a later stage using the Ogunniyi's Contiguity Argumentation Theory (CAT). The findings of the study show that the learners' post-conceptions on selected mechanics topics were influenced by their local worldview presuppositions and could be analysed according to the CAT worldview categories.

**Keywords:** alternative conceptions; Contiguity Argumentation Theory; indigenous knowledge; integration; mechanics; scientific knowledge; socio-cultural constructivism; worldview presuppositions

## Introduction and Background

Numerous empirical studies have noted the influence of the worldviews held by educators and learners on the teaching and learning of science (Chan & Wong, 2014; Jegede & Okebukola, 1991). The authors argue that non-western learners exposed to western school science experience a conflict between the worldviews obtained from their socio-cultural life experiences and those taught in science classes (Fakudze, 2004; Le Grange, 2007). These studies argue that the held worldviews may impede the acquisition of scientific concepts within a science classroom, resulting in alternative conceptions that could lead to poor academic performance and dropping out of school, which in turn could end up in learners' long-term indifference towards formal science education (Semali & Mehta, 2012).

In this article we adopted the definition of worldview used by Ronald (2015) who describes it as mental frameworks that define how people understand their relationship to their socio-cultural environment. She argues that worldviews are formulated by the spiritual ways that have been incorporated in people's behaviour patterns, their traditions and everyday practices. Keathley (2007), on the other hand, describes a worldview as people's search for answers to life's most essential questions and it can influence the way in which people look at, among others, life, death, religion, parenting, education and politics. Mathema (2007) added that the worldview acts as the centre of similar cultural expressions and permeates everything that a group does and thinks by providing definitions for reality, values and truth. In this paper, the worldviews will be used interchangeably with indigenous knowledge systems (IKS).

### Literature Review

Several science education researchers have made suggestions on how to align learners' everyday life experiences and school experiences within socio-cultural realities (Abah, Mashebe & Denuga, 2015; Mpofu, Otulaja & Mushayikwa, 2014a, 2014b; Semali, 2013; Semali, Hristova & Owiny, 2015). They have advocated for a science curriculum that integrates the learners' indigenous knowledge and school science to help bridge the gap between the learners' prior knowledge and that encountered in the science classroom. In this way, indigenous and Western philosophies, beliefs, and spirituality will not be taught in opposition nor in isolation (McCallum, 2012). Taylor and Cameron (2016) recommend a theory that would address ways of valuing IKS in science teaching and learning situations. They have identified a third perspective where IKS and science are viewed as intersecting domains. Furthermore, Naidoo and Vithal (2014) have put forth three approaches, namely, incorporationist (best fit), separatist (side by side), and integrationist (connections) between IKS and science.

Some of these researchers have proposed the integration of indigenous knowledge held by learners with the science curriculum in order to make it culturally relevant, thus enabling learners to view science as a human enterprise and not as an esoteric subject to be encountered only in the school environment (De F. Afonso Nhalevilo, 2013; Khupe, 2014; Kim, 2015). The prime aim is to provide a teaching/learning situation in science that makes it possible for learners in indigenous settings to have easier access to science through overt comparisons of their worldviews and that of science. In this article we adopt the integrationist approach.

There have been many reports on integrating IKS and school science in multi-cultural science classrooms, such as those in South Africa, Canada and New Zealand, but very little has been reported on culturally homogenous classes as in this study (Brown, Muzirambi & Pabale, 2006; Khupe, 2014). Swazi science classrooms are culturally homogeneous, with both learners and teachers strongly grounded in the Swazi culture. They live by coherent traditional beliefs. This was attested to by an earlier study (Fakudze, 2003) on border crossing from an indigenous worldview to a scientific worldview and vice versa. The learners in the study were found to have exhibited the indigenous worldviews that fell under the following categories:

*Magic category*: Magic is an art that purports to control or forecast natural events, effects or forces by invoking the supernatural (Jobe, 1962; Ogunniyi & Yandila, 1994; The Webster Comprehensive Dictionary, 1995).

*Spiritism category*: An example of rare animism, which is a theory that inanimate objects possess spirits. It is also loosely regarded as a form of spiritualism, which is the belief that the spirits of the dead communicate with and manifest their presence to the living in various ways. It is an appeal to another world of gods, spirits, devils, ancestors, etc. (Ogunniyi & Yandila, 1994; The Webster Comprehensive Dictionary, 1995).

The Swazi's worldviews were assumed to have been influenced by spiritual ways that had been incorporated in their behavioural patterns, traditions and daily practices (Ronald, 2015).

### Theoretical Framework

The study is situated within a worldview theory as espoused by socio-cultural constructivists (Aikenhead, 1996; Jegede, 1995; Ogunniyi, 1995). Literature shows that science education research has since moved to the concept of argumentation as a possible teaching and learning strategy (Fakudze, 2015). Ogunniyi (2007) posits the CAT as an explanatory model for analysing the processes that an individual's thought system undergoes when confronted with new information such as school science, in the case of learners whose thought systems are different from the latter. He argues that this explains a dialogical framework for resolving the incongruities that normally arise when two (and sometimes multiple) competing thought systems (e.g. science, IKS, cultural beliefs, commonsensical, or intuitive notions) are placed side by side (Ogunniyi, 2007).

Ogunniyi (2007) identified five categories of adaptive cognitive co-existence that can occur in the learners' minds as they receive the incoming science information, namely, dominant, suppressed, assimilated, emergent, and equipollent – depending on the nature of the arousal context or the claims to be defended or refuted in the attempt to attain a sort of cognitive harmonisation, or allostasis.

Whereas the CAT (Ogunniyi, 2007) was designed as two-directional and the five categories could thus be used for describing ways of cognitive co-existence in multi-cultural science classrooms, this paper adapted and expressed these categories in terms of worldviews that could play out among indigenous learners in a science classroom. The following will be used to analyse the data:

*Dominant scientific worldview*: The learner's thought system is agreeable to the science concepts presented in the science lesson.

*Dominant indigenous worldview*: The learner's thought system decidedly holds on to the indigenous worldview, prevailing in the socio-cultural environment regardless of his/her awareness of the scientific concepts presented in class.

*Assimilated worldview*: The learner abandons his initially indigenous presupposition and adopts the new science concepts in the class.

*Equipollent worldview*: The learner holds on to both indigenous and scientific worldview presuppositions. He expresses his views unashamedly depending on the context in which he finds himself.

*Suppressed worldview*: The learner tries to emulate the science conceptions while pressing down his own indigenous worldview in order to pass the exams.

*Emergent worldview*: The learner is confronted with a new way of looking at a phenomenon.

For the purpose of analysing the results of this study the above worldview categories will sometimes be combined with Ogunniyi and Yandila's (1994) magic and spiritism categories.

## Methodology

### Participants

The study described in this article was part of a larger study in which a quasi-experimental design involving three schools from which learners from intact classes were selected rather than through randomisation. The schools were selected because they were all situated in the same rural region, which meant that the learners were likely to have been exposed to similar socio-economic conditions, and were probably familiar with the traditional practices found in that particular socio-cultural environment. For the purposes of this paper only the experimental group will be considered. The participants were part of an intact Grade 11 class comprising of 51 learners made up of 27 boys and 24 girls. Ten of these learners were later chosen to participate in a focus group interview based on their responses to the PAT. The teacher was an experienced middle aged female who had taught physics for more than 20 years.

### Intervention

All of the learners had been exposed to scientific and indigenous worldviews through their interaction with an indigenous community and through the science lessons at school. The learners had also been exposed to an intervention in which a socio-culturally-based teaching/learning strategy had been used that integrated selected indigenous knowledge presuppositions into school science designed specifically for this study. The socio-cultural instructional model (SCIM – see Appendix B) is different from other later interventions in that it does not use an argumentation-based programme (Diwu & Ogunniyi, 2012; Moyo & Kizito, 2014), but instead uses whole class discussion. It is also different from Mpofu et al.'s (2014a, 2014b) study in which a grounded theory approach for the generation of data was used.

### Research Instruments

1) A PAT was administered to test the learners' performance on the topics. The PAT questions (Appendix C) were extracted from several textbooks and were modified by: contextualising them; embedding them within stories, anecdotes and life histories of Swazi people, and situating them in the beliefs and values of Swazis. The PAT was validated by content and construct validities. For content validity the PAT represented an attempt to maximise content validity or appropriateness based on the set of objectives force, energy, work and power under the physical science syllabus for Swazi schools.
2) A focus group interview schedule
   A video recorder was used to record a discussion on the learners' views concerning two phenomena found in their socio-cultural environment based on two of the questions in the PAT.

### Analysis Instrument

Data obtained from the selected PAT questions were analysed in terms of excerpts derived from the learners' viewpoints regarding the socio-cultural phenomena found in their immediate surroundings. The learners' videotaped discussions were analysed in line with the CAT lenses.

## Results

Only Questions 2.2, 2.3, 5.1, 5.2, 9.6 and 9.7 are discussed in this section of the paper because they deliberately included worldview suppositions.

### The Influence of the Worldviews Presuppositions on Learners' Conceptions on Mechanics, as Illustrated in Their Responses to the PAT Questions

Six questions in PAT, Questions 2.2, 2.3, 5.1, 5.2, 9.6 and 9.7, deliberately included worldview suppositions found in the learners' socio-cultural environment and were used to test their influence on the learners' indigenous and scientific predispositions. This was done by considering samples of the learners' pre- and post-responses to check whether the learners had changed after the intervention. These responses were analysed according to Ogunniyi's (2007) CAT modified for the purposes of this study. Only two types of worldviews were observed from the PAT: dominant indigenous and emergent worldviews.

#### *Dominant indigenous worldview in PAT*

To further investigate the influence of the beliefs prevailing in their socio-cultural environment, Question 2.3 required of the learners to describe what would happen if the rule of not bringing water into a homestead after sunset were to be broken. Thirteen of the learners seemed to display a dominant indigenous worldview. They seemed to decidedly hold on to their communities' indigenous worldview regarding this phenomenon, regardless of their awareness of the scientific concepts that had been presented to them in class during the SCIM intervention. For example, three of the learners (S5, S6, and S7) wrote the following reasons in the pre- post-tests, as seen in following verbatim excerpts. They wrote similar comments in the pre- and post-tests.

One learner wrote that bringing water after sunset would affect the weather conditions:

> S5 (Pre-test): *Because in old days they believe that the water can caused danger. There will be a storm or heavy rain accompanied by thunder and lightning.*
>
> S5 (Post-test): *Its superstition that when you bring water after sunset there will be heavy rains in your homestead. We believe that there will be rains in her homestead.*

Another learner wrote about exposing the family to witchcraft:

> S6 (Pre-test): *She has the fear of spokes* (tipoko) because water must not enter home during spokes time. The water would be entered by evil spirits power which is not good.*
>
> S6 (Post-test): *Her family believes in witchcraft. They think that water can be witched by spoke when the sun is not seen. The water was not going to enter the home.*

The third learner wrote about lightning:

> S7 (Pre-test): *Swazis tradition state that water must get to home before sunset. Her homestead might be struc by lightning.*
>
> S7 (Post-test): *It is because of the Swazi custom. Her homestead would be strucked by lightning.*

Furthermore, when using Ogunniyi and Yandila's (1994) categories, the responses of learners S5 and S7 in the pre- and post-tests could also be classified as dominant indigenous worldview, falling under the magic category, because they believed purporting to control or forecast natural events, effects or forces by invoking the supernatural. The responses of learner S6 in the pre- and post-tests displayed the spiritism category of dominant traditional worldview, which is the belief that the spirits of the dead in various ways communicate

with and manifest their presence to the living.

Question 9 (see Appendix C), consisting of seven sub-sections, was about a woman, la-Simelane, who was hoeing her maize fields using a 20N hoe. The first three sub-questions required the learners to describe the types of energies undergone by a hoe at three different points as a woman hoeing her fields raised it up and down. The PAT results showed that 40% got correct answers for the first five sections. The results based on questions 9.6 and 9.7 in the pre- and post-test in the PAT also demonstrated the effect of the worldviews on their conceptions with regards to some indigenous practices and customs prevalent in the learners' socio-cultural environment. These questions required the learners to explain why a woman, la-Simelane, did not work in her fields when a funeral was taking place in her area. They were also asked to explain what they thought would happen to her if she went ahead and weeded her fields. The learners' pre- and post-test comments seemed to exhibit a dominant indigenous worldview. The following are some of the comments from the pre-test and post-test made by three of the learners.

> S1: *It is because it is customed that don't toach soil when there is a funeral. There was going to have a hailstorm, which destroys the fields.*
>
> S2: *It was because when there was funeral you must not dig the soil. There was going to be a lot of wind and rain.*
>
> S3: *It is she prevent thunder, storm and heavy wind. The maize will die because of heavy storm and heavy blowing wind.*

According to Marwick (1966), no work is done in the fields when a death has occurred in a Swazi village. The above comments seem to attest to that. The same learners made similar comments even in the post-test:

> S1: *It is because she believed that there would be the hailstorm. There would be the hailstorm which will destroy all the crops.*
>
> S2: *It is because when there is a funeral people were not allowed to hoe. There will going to have heavy rain and destroyed her field.*
>
> S3: *When there is a funeral touching soil is not allowed. They will be heavy storm that would destroy the plants.*

One learner gave a reason that was slightly different from the ones above. He said that touching the soil when a funeral was taking place hardened the soil.

> S4: *Traditionally, they say you do not work on the soil as proceedings at the funeral take place. People of her area would tell her they would do the same if one member of her family dies so that the soil is hard for those digging for the body.*

In the post-test, the learner said something similar to the above statement:

> S4: *Traditionally they say the soil will be hard for those who are digging if a person in the same area is working on it. Some say they will also not help you when a member of your family dies. Nothing, but she would give the people a wrong picture in mind and would be charged a (inhlawulo) penalty by the indvuna of the area.*

The pre- and post-test responses exhibited a dominant indigenous worldview, falling under the spiritism and magic categories. In the former, the spirit of the dead person made the soil hard. In the latter, magic would invoke the supernatural to control natural events such as storms and thunder. According to Marwick (1966), no work is done in the fields when a death occurred in a Swazi village. The above comments seem to attest to that. The Swazi community in which the learners lived believed such regarding this phenomenon. They said that touching the soil when a funeral was taking place hardened the soil (e.g. S4). Not only would the offender face the issue of symbolic and psychological violence but possible banishment by ostracism.

### *Emergent worldview in PAT*

Question 2, which had three sub-sections, was concerned with a girl, Siphiwe, who used a wheelbarrow to fetch water from the river. The learners were given a drawing of the wheelbarrow with three points marked on its handles. They were supposed to use their knowledge to identify the best position at which Siphiwe could handle the wheelbarrow. The question was answered correctly by 88% of the learners, in that they chose P (Figure 1) as the easiest point for handling a wheelbarrow.

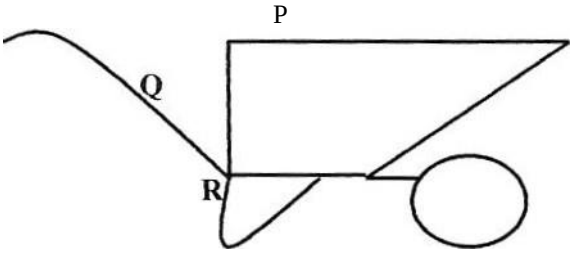


**Figure 1** A wheelbarrow (adapted from Fakudze, 2003)

In order to test what influence the socio-cultural environment had on them, the learners were asked in Question 2.2 to explain why water should not be brought into a Swazi homestead after sunset. This is because one of the Swazi beliefs says that if one puts a coal in water that has been fetched after sunset, the one carrying it will be protected from the ghosts. Two of the learners exhibited an emergent worldview when explaining this question. They started off by explaining the phenomena using a traditional worldview and ended up, after the intervention or after a discussion with others, trying to use the new scientific worldview thus revealing that they had undergone some emergent worldview shift. The one learner, S8, mentioned this in her pre-test

comment. However, her post-test comment revealed an attempt at explaining the phenomenon in a scientific way, which ended up with a misconception. This seems to show that she was probably trying to alter her response by reconstructing the original schema under the influence of the newly encountered schema:

> S8 (Pre-Test): *She would put a coal in the water*.
> S8 (Post-test): *Use little energy and do more work. She would use more energy and little work would be done.*

The other learner, S9, also started off with a traditional worldview at the pre-test stage but ended up with an alternative conception at the post-test stage as follows:

> S9 (Pre-test): *She does not want to bring evil spirits into her home. Evil spirits would be in her home and there would be no peace*.
> S9 (Post-test): *It is because when the sun sets there will be more weight on the wheelbarrow. It would have took her a longer time to reach her destination.*

Both these learners' post-test comments revealed an attempt to explain the phenomenon in a scientific way, but ended up with alternative conceptions, showing that they were probably trying to alter their responses by reconstructing their original worldview under the influence of the newly encountered worldview of school science. The two learners seemed to have contrasted their traditional beliefs with the scientific ones encountered in the science class, and then altered and reconstructed them under the influence of the new scientific knowledge.

Question 5 (see Appendix C), divided into sub-sections, was about Mandla and his friends who brought the catapults they used for killing birds to school. The learners' responses seemed to reveal that the science lesson was giving them new ways or lenses to describe some familiar phenomenon, thus giving them some emergent worldviews on the use of catapults. Question 5.1 tested the learners' abilities to design an experiment showing how the elasticity of the catapult varied with force. Only 50% of the learners answered correctly. Some of the learners' responses were:

> *They hold the catapults and apply different force to the catapults. More energy will cause the catapult to move a long distance than less force applied.*
> *They stretch the catapults with a stone in it. Then the release the stone by allowing the belts to retain their normal positions.*
> *Mandla handled the catapult with one of his hands and he pulled the catapult with his potential energy and the catapult remains stretched with potential energy.*

The list above is the learners' attempts to describe the use of catapults in killing birds. Their intuitive responses were in terms of their own experiences with properties of good catapults.

In Question 5.2 (see Appendix C), the learners had to interpret a graph representing the change in the length of the catapult against the forces used to stretch it. They had to be able to tell if it obeyed Hook's law or not. They all explained that the graph did not show that the extension of the catapult was directly proportional to the force applied to it, and that there was no limit of proportionality on the graph. The results show that the learners received a mean percentage of less than 50%. Some of the learners' responses were as follows:

> *Yes, because he did not stretch the catapult beyond its limit of elasticity*.
> *Yes, because Mandla's catapult had a limit of proportionality*.
> *Yes, because the length of the extension increased when a force was applied*.
> *Yes, because it did not get into its normal length after stretching it.*

Once again, the above illustrate that the learners were experiencing an emergent worldview. They were given new terminology for describing a phenomenon that they were used to seeing in their socio-cultural environment, that is, the use of catapults.

### The Influence of the Worldviews Presuppositions on Learners' Conceptions on Mechanics as Illustrated in Their Responses in the Focus Group Interview

The influence of the socio-cultural worldviews on the concepts of principles of a moment and efficiency was further probed by using a focus group interview based on two fictitious stories (see Appendix A) (Fakudze, 2003, 2004). The learners' responses were classified as dominant indigenous, equipollent, suppressed and assimilated, according to the CAT (Ogunniyi, 2007).

#### *Dominant indigenous worldviews from focus group interview*

Two of the learners still held on to their indigenous beliefs despite the fact that they had been exposed to science lessons that took their cultural beliefs into consideration. For example

Story one

> Zandile*: I think this botikoloshe contributed to the Zandile's fatigue. The fact that his father told her ... it meant that the father had experienced the khombos (bad luck) that were going to arise when you arrive with the water at night. So because her grandmother and also his father spoke almost the same thing it means there was a connection in the spilling of the water against the evil spirits, botikoloshe, which means the water was now having botikoloshe.*

Story two

> Sipho: *I think it's because of the ancestors, because of Mr Ngwenya's indigenous medicine, his ancestor's medicine because they can work over a*

*distance*.

*Suppressed worldview from focus group interview*

An example of a suppressed worldview occurred when Khangezile started scolding the group, saying that they must not answer foolishly because the teacher wanted to see if they had learnt the scientific concepts. She said this, holding her physics notebook, which she then opened and tried to explain the phenomena using the physics notes copied from class. She said:

Story two

> Khangezile: *The witchdoctor was not right: he had heard rumours. Mr Ngwenya, as our teacher said, he forgot to change the oil and the diesel. So the machine had maybe died or become tired. So it was unable to do work what I can say is that in our Physics our teacher told us that efficiency is the work done over energy input. So the machine was doing less work than the energy put in due to petrol and diesels, which were not changed.*

It seems as if Khangezile was serving a human interest: that of pleasing the teacher. She seemed to have been suppressing her own indigenous worldview by trying to adhere to the science teacher's. She was unable to explain the phenomenon using her own words, but instead relied on the notes she had taken in class. What is more, it seems as if Khangezile was experiencing the dynamic interplay between or among dominant mental states, constituting a worldview template that probably governed her thoughts and actions. Perhaps the Swazi indigenous worldview, commonsensical knowledge, and the scientific worldview are being repositioned such that they ultimately lay contiguously. In other words, a sort of cognitive wrestling of schemata was probably occurring (Ogunniyi, 1995), which eventually capitulated to the dominant one, in this case, the scientific worldview in order to please the teacher.

*Assimilation worldview from focus group interview*

Evidence of assimilation was seen when one of the learners went to the extent of arguing that education ought to change their cultural beliefs, while others thought otherwise. Their initially (indigenous) held thought system was supplanted or subsumed by the dominant worldview (scientific worldview within the science class).

> Thoko: *I just like to tell you that we adopt these beliefs from our forefathers but that we have to come out from this thing. It will affect our future ... Now we are educated. Our forefathers were not educated that is why they believed that.*
>
> Vusi: *Does this mean that we have to change our cultural beliefs*?
>
> Thoko: *No, we are not supposed to change our culture but we have to see something that is not true*.

*Equipollent worldviews from focus group interview*

Evidence of *equipollent* worldviews emerged when one of the learners shifted between indigenous and scientific worldviews trying to explain the second story.

Story two

> Langa: *But as far as I am concerned, the fact that the oil was old also contributed to the efficiency of the machine. Although the oil was also old it means that the machine was working not in the right condition because it was consuming less oil, which is old, and also producing less work. Then on the other side of this tinyanga people, I will say that they ... with the working of the machine. This Inyanga, the Dlamini one, told Mr Ngwenya that what he is going to see because he has insulted him, he has done wrong ... He is going to see a wonder which means his ... his chain saw. I say that this got an effect because why then at the end it was the chain saw that got the problem?*

*Dominant scientific worldview from the focus group interview*

One of the learners in the focus interview group exhibited a dominant scientific worldview as she tried to explain the two fictitious stories using the principle of moments concept and efficiency.

Story one

> *My friend, O.K. What does the principle of moments say? They say when an object is in equilibrium its sum of anticlockwise moments is equal to ... Let's say Zandile held the wheelbarrow closer to the equilibrium, so that's why it was heavy. Then she used more energy when going than the work she did. She used more energy than what she was supposed to use ... Then she ran which meant more energy was used. I think that is why she was lacking energy.*

Story two

> *... I don't agree about the witch doctor told him because when something is less efficient it uses a lot of energy to produce something less. I think the saw was now in its abnormal state so it was not its normal so while using it Mr Ngwenya while he was using it, it take a long time to do less work. So the inyanga is not telling us the truth about what happened to Mr Ngwenya and the other man who were fighting because of that they were drunken ... The saw was less efficient. Full stop.*

**Conclusion**

The aim of the study was to investigate whether or not the conceptions held by Grade 11 learners of selected mechanics topics were influenced by the worldviews presuppositions prevalent in their socio-cultural environment after exposure to an intervention that integrated school science and IKS. Both the quantitative data from the PAT and the qualitative data from the videotaped focus group

interviews indicated that, despite the learners' achievement in their conceptions of mechanics, their thought systems seemed to indicate that some of these learners had undergone some shifts in their worldviews presuppositions that collaborated with CAT's (Ogunniyi, 2007) categories of dominant indigenous worldview, equipollent worldviews, and assimilation. The learners' responses in the focus group interviews showed the learners shifting between worldviews supporting Ogunniyi's (1997) notion that worldviews are dynamic and depend on the situation at that point and time. Only one of the learners in the focus group interview could display evidences of scientific worldview thus confirming the difficulties experienced by non-Western learners in trying to learn science topics (Ogunniyi, 1997).

Several science educators have pointed out the need for curriculum developers in indigenous communities to recognise the role that the indigenous knowledge held by learners can play in the development of positive attitudes towards the learning of science in indigenous societies (Jegede & Okebukola, 1991). This could be done in order to develop a culturally relevant science curriculum that enables learners to view science as a human enterprise, not as an esoteric subject to be encountered only in the school environment (De F. Afonso Nhalevilo, 2013; Diwu & Ogunniyi, 2012; Hewson, 2012; Khupe, 2014; Kim, 2015). The prime aim is to provide a teaching/learning situation in science that makes it possible for learners in indigenous settings to have easier access to science through overt comparisons of their worldviews.

## Notes

i. Published under a Creative Commons Attribution Licence.

ii. DATES: Received: 5 July 2019; Revised: 6 February 2020; Accepted: 13 March 2020; Published: 31 May 2021.

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**Appendix A: Fictitious Stories for Videotaped Group Discussion**

Story One

Zandile Dlamini grew up in the Dlamini homestead where her father had given instructions to her and the other children that they must never ever bring water to the homestead after sunset. The reason for the instructions was that if you bring water from the river after sunset evil spirits will attack the home, as botokoloshe will be contained in the water. Zandile did obey her father, but one particular day Zandile played for her netball team at school and she came home very late, when the sun was about to set. She took the wheelbarrow and went to the river to fetch water. When she got there she filled up the container with water and put it on the wheelbarrow. Now in order to get home faster she decided to hold the wheelbarrow in a particular way. She started to push it up the slope, but in the process, she sweated a lot, loss a lot of water as the water began to spill and she took longer than usual. When she was about to enter her home her foot got into a hole she tripped, fell and broke her ankle. Zandile, then picked up the wheelbarrow that had fallen also and drove it into the homestead, but her grandmother had watched all what bad just happened with her. Zandile's grandmother called her to her hut and said to her "what has happened to you is because you have broken your father's instructions you have brought water into homestead after sunset, the water that contains botokoloshe (evil spirits)", and she ordered Zandile to throw away all the water.

*Questions*

- Do you agree with Zandile's grandmother that Zandile hurt her ankle because of the evil spirits that came in with the water and that the water that was brought home after sunset was containing evil spirits (botokoloshe)?
- If you don't agree with Zandile's grandmother what is your opinion about what happened to Zandile?
- What do you think made her very tired?
- What made her sweat a lot?
- Why did she take a very long time to bring the water home? What made her hurt her ankle?

Story Two

Mr Ngwenya drinks a lot especially during the maganu season he would drink until he forgets his name. Mr Ngwenya is also working for Shiselweni forestry and he uses a chain saw, which needs oil that must always be replenished to work properly. One day he went to a shebeen to drink and he met Mr Vilakati who was known to be a feared witchdoctor of the area, they drank together but later a fight started between the two, after which Mr Vilakati sustained injuries and he swore that he was going to bewitch Mr Ngwenya for what he has done to him. Mr Ngwenya who was obviously worried about the threats, went to sleep, the following morning he went to work but he had forgotten to replenish the oil for his chain saw. His foreman gave him notice that due to his poor performance he would be fired if he doesn't improve. Mr Ngwenya's became worse as he got more worried; he decided to consult a certain witchdoctor, Mr Dlamini about his situation at work. Mr Dlamini, the witchdoctor told Mr Ngwenya that the chain saw was not working properly because of Mr Vilakati's curse; he had bewitched the machine that's why it cannot cut the wood faster.

*Question*

Do you agree that the chain saw was affected by Mr Vilakati's curse or what do you think affected the chain saw?

**Appendix B: Socio-Cultural Instructional Model**

The socio-cultural instructional model (SCIM), designed by Fakudze (2004), integrated selected indigenous worldview presuppositions with school science on the learners' conceptions of Selected Mechanics topics. The SCIM was designed using recommendations from different studies that included, among others,

- Generating information about the student's everyday environment to explain natural phenomena (Jegede, 1995; Manzini, 2000);
- Using teaching/learning materials that are simple, relevant to the context, and matching the developmental level of the students (George, 1999);
- allowing class discussions that include considerations of worldview cultural perspectives and other more metaphysical concepts (Lawrenz & Gray, 1995);
- increasing the time for discussion in class because of the differences in the perceptions of the students; and
- applying a teaching manner and style that encourages active observation, interpretation, and explaining on the part of the students.

Example of a Lesson Using SCIM

During lesson delivery concepts would be taught by intermingling them with applications to the traditional settings that were discussed during the lesson introduction. The learners are encouraged to voice their views by basing the topic under discussion on the learners' immediate socio-economic environment.

| Question | Scientific concept | Socio-cultural traditional setting |
|---|---|---|
| 2 | Moment of a force | Fetching water from the river using a wheelbarrow |
| 5 | Elasticity varied with force, Hooke's Law, limit of proportionality | Using catapults to kill birds |
| 9 | Kinetic and potential energy | Using a hoe in a maize field |

**Appendix C: Analysed Questions in PAT**

Question

2. Siphiwe always uses a wheelbarrow to fetch water from the river when she returns home from school because she finds it easier to use it than carrying the water on her head. However she has also realised that even the wheelbarrow can be difficult to push when its handles are held incorrectly.

2.1. At which point P, Q or R did Siphiwe find it easiest to push the wheelbarrow?

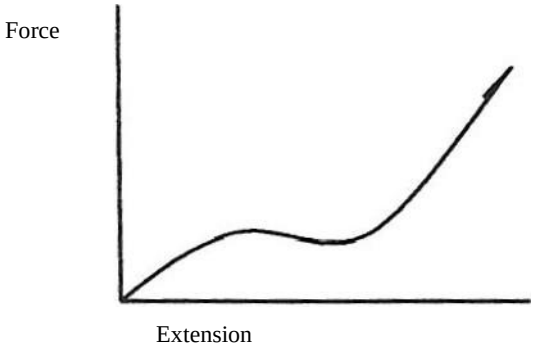
2.2. Siphiwe has to also make sure that she brings the water into her homestead before sunset. What could be the reason for this?

2.3. What would happen if Siphiwe disobeyed this?

5. Mandla and his friends like killing birds using catapults (tilingi). One day they brought their catapults to school and their science teacher asked them to design an experiment to show how the catapults stretch whenever they pull them with different forces.

5.1. Outline the steps Mandla and his friends followed in doing the experiment.

5.2. When Mandla plotted the results of his experiment, he got the graph shown below:




Did Mandla's catapult obey Hooke's law? Justify your answer.

9. Whenever la-Simelane hoes (kuhlakula) her maize fields, she prefers a 20N hoe which she raises 2 m above the ground. Describe in terms of terms of kinetic and potential energy the energy undergone by the hoe at three different positions.

9.4. How much energy has la-Simelane's gained at the highest point?

9.5. At what speed does the hoe hit the ground each time la-Simelane brings it down?

9.6. La-Simelane did not work in her field the previous day because there was a funeral in the area, even though she did not attend. Why didn't La-Simelane hoe her maize field?

9.7. What could have happened if La-Simelane went ahead and worked in her field?