Secondary school learners' response to the teaching of evolution in Limpopo Province, South Africa

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ABSTRACT: *One of the major causes of the problems affecting evolution education is lack of acceptance of this concept, particularly by some of the people who have strongly entrenched religious beliefs. This paper reports part of a study which explored the influence of the beliefs of learners in some secondary schools from the Vhembe District in the northern Limpopo Province, South Africa, on the teaching and learning of biological evolution. A questionnaire was administered to Grade 12 learners studying Life Sciences, to which 348 responded. Data were analyzed to provide descriptive and inferential data for analysis. Findings indicated moderate acceptance of evolution by the learners. Some of the factors which showed an association with learners' acceptance included: learners' religious beliefs, age, and the time since they had first heard of evolution. Although some learners experienced conflict between their religious beliefs and evolution, findings showed that most were willing to learn about it.*

Key words*: biological evolution, creation, evolution acceptance, religious beliefs, worldviews*

Introduction

One of the latest developments in the curriculum of South African secondary schools has been the addition of evolution to the Life Sciences subject in 2008. Research has been carried out locally in relation to evolution education in schools and universities. Some studies have

focussed on the perceptions of teachers and prospective teachers (Abrie, 2010; Sanders and Ngxola, 2009), and the understanding of evolution by preservice teachers (Chinsamy and Plaganyi, 2007). Recently, more studies have looked at the misconceptions held by high (secondary) school students (Kagan and Sanders, 2012). If teachers hold misconceptions about evolution, they are likely to teach those misconceptions. This can lead to lack of understanding by learners as well as to non-acceptance of evolution (Abrie, 2010).

A study by Sanders (2010) found that some teachers use methods that are not appropriate for dealing with the controversy and complexity of the concept of evolution. They did not use methods where learners' views were incorporated resulting in lack of accommodation of differences of opinion in class (Sanders, 2010). Learning in this kind of atmosphere may prejudice learners against the concept of evolution, with learners having a distorted view of evolution and rejecting it outright.

Evolution accounts for about 25% of the content in Grade 12 Life Sciences curriculum, a percentage high enough to influence performance in examination. It has been examined since 2008 and reports of examiners indicate poor performance in it, which should be a matter of concern to Life Sciences educators. The design of the current curriculum in South Africa is underpinned within constructivism, a theory that posits the recognition of prior ideas in teaching and learning. Prior ideas include any knowledge and beliefs that learners bring to the classroom. However, little is known about what beliefs learners have about evolution and how such beliefs could influence their understanding and acceptance of the topic.

Research Question

The intention of the research was to answer the following question:

What do learners understand and believe about evolution, and how do their understanding and beliefs influence their learning and acceptance of evolution?

Challenges facing evolution education

There is general agreement among the scientific and science education communities that evolution represents a major scientific concept that is central and unifying to the biological sciences (Dempster and& Hugo, 2006; Hokayem and BouJaoude, 2008; Rutledge and Mitchell, 2002). However, evolutionary theory does not receive appropriate emphasis in high (secondary) school Biology curriculum and classrooms, with its teaching fraught with misinformation (Dempster & and Hugo, 2006; Rutledge and Mitchell, 2002). The main result of not treating evolution as a unifying concept is poor Life Sciences teaching which further denies Life Sciences a stake in the achievement of scientific literacy.

A major challenge that faces biological evolution is rejection by some people, especially the religious fundamentalists who feel that evolution is in conflict with creation theories as given in the scriptures. Some fundamentalists hold to "a view that stresses the inerrancy of Bible" (Athanasiou, Katakos, & Papadopoulou, 2012, 240). Scott (2000) identifies the Biblical-literalist Christians, ultraconservatives, Jews and Koranic-literalist Muslims as those who object to evolution in the United States. Creationists hold that God created the various sorts of life. Religious opposition to evolution may lead to anti-evolutionism, even though not all people who accept creation reject evolution. Evolutionism and creationism can be regarded as opposites of each other reflecting different worldviews: naturalism and theism. Creationism exists in many forms (Reiss, 2009). These different levels of 'creationisms' have been categorized in a creation/evolution continuum (see Scott, 2000). The acceptance of evolution seems to vary according to the different levels.

The implications of these varying beliefs is controversy around evolution, which relates sometimes to whether evolution only should be taught, or creationism as an alternative explanation, or both. Considering that acceptance of evolution is sometimes influenced by people's religious beliefs, it can be hypothesized that those learners who have a religious background will not accept evolution. This is reflected in the following null and alternative hypotheses:

The null hypothesis (H_o): There is no association between learners' background and acceptance of evolution.

The alternative hypothesis (H_a): There is an association between learners' background and acceptance of evolution.

Theoretical perspectives for the research

Considering that this research was about people's beliefs, the worldview theory was adopted to underpinn the study. A worldview is an overall collection of beliefs about the universe and life through which an individual sees and interprets the world; it is an individual's understanding of prime reality (Anderson, 2007, 671; Kearney, 1984, 42; Smith, 2010). Kearney (1984, 1) refers to the worldview as "culturally organised microthought: those dynamically inter-related basic assumptions of a people that determine much of their behaviour and decision making, as well as organizing much of their body of symbolic creations".

The concept of worldview has received much attention in the science education literature as a topic of analysis, discussion and empirical research (see Anderson, 2007; Cobern, 1991; Hokayem and BouJaoude, 2008; Lawrenz and Gray, 1995; Reiss, 2009). Worldviews vary from group to group according to each group's perceptions of reality. Philosophical and religious beliefs are not identical with worldview, but are intimately linked and hence an important part of the worldview content (Cobern, 1991). Worldviews, like beliefs, are not

observable. Cobern (1991) refers to religion and philosophy as visible expressions of worldviews and beliefs.

With evolution sometimes being such a contentious issue, worldviews are sometimes related to the evolution controversy. In his examination of worldviews, James Sire discusses eight categories: *naturalism*, *theism, deism*, *nihilism*, *existentialism*, *Eastern Pantheistic monism*, *New Age* and *postmodernism*. Of these, the two most relevant to this study are naturalism and theism. Naturalism is a form of materialism, in that it treats matter as all that exists, with no supernatural, no history, no purpose (Smith, 2010). By not admitting non-physical explanations of nature, the scientific worldview is materialistic (Reiss, 2009) and a form of naturalism. According to Sire (2009, 67), in theism God is the infinite personal creator and sustainer of the cosmos, while in naturalism, God loses His existence. Therefore, naturalism refers to the belief that material forces are the basis for evolution, whereas theism considers the involvement of God or the supernatural in the processes of evolution

While there is some correlation between worldviews and religion, a person with a theistic worldview is not necessarily religious (Anderson, 2007, 672). Scott (2000) has described a continuum that exists between naturalistic and theistic beliefs regarding evolution which correlates implicitly to the evolutionism/creationism continuum.

Methodology of the research

Sample

The main sources of data were learners of Grade 12 Life Sciences where evolution is taught. The study took place in the Vhembe District which is situated in the former Venda homeland in what is now the Limpopo Province. The population for the study was divisible into sub-groups, defined by the areas in which the various schools were found, such as urban, semi-urban, and rural. A number of schools fitting the three criteria were thus identified and

approached to request permission from principals to conduct the study. Those schools that would be easily accessible during the research were preferred, so to this extent convenience selection was employed. . The 483 Grade 12 Life Sciences learners in the selected schools therefore became the survey sample and 348 (72.05%) of them filled the questionnaire.

Data collection procedures and validation

Ethical clearance was obtained from the Ethics Committee of the Faculty Education prior to the administration of the questionnaire. The questionnaire was pilot-tested with a convenience sample of 10 in the year before data collection for the main study.

The questionnaire had three sections: Section A – ten (10) closed-ended for biographical data and one open-ended item asking for a single comment about evolution, Section B –Likert scale Measure of Acceptance of Evolution Theory (MATE), and Section C – eight (8) open-ended items soliciting learners' beliefs and opinions about the teaching and learning of evolution. The MATE was meant to indicate the extent to which learners found evolution acceptable. This measurement used an ordinal scale with opinions labelled 'strongly agree', 'agree', 'disagree' and 'strongly disagree'. To design this measurement, a 20-item Likert-scaled instrument, developed to assess overall acceptance of evolution among high (secondary) school biology teachers and validated by Rutledge and Warden (1999) was adapted. Items added to MATE by Cavallo and McCall (2008) were added to "evaluate overall [learner] perceptions of evolutionary theory" (Cavallo & McCall, 2008, p. 526). Its reliability was further determined for university students (Rutledge & Sadler, 2007). It has been used at college level to assess the acceptance of evolution by Biology students (Hokayem & BouJaoude, 2008) and by pre-service teachers (Deniz *et al*., 2008).

To adapt it for use in this study, where the subjects were secondary-level learners, the instrument was subjected to reviews by experts in Biology education and in research

methods. This was followed by changes in the instrument, by which some items were re-worded to make them easy to understand and respond to by a Grade 12 learner. An example is the item which read "*Current evolutionary theory is the result of sound scientific research and methodology*", which was split into "*Current evolutionary theory is the result of sound scientific research*" and "*Current evolutionary theory is the result of sound scientific methodology*". One item was not included in this study because, in the original Rutledge and Sadler's (2007) MATE, there were two items with the same content where one was stated positively and the other stated negatively. The two items were "*Evolution is not a scientifically valid theory*" and "*Evolution is a scientifically valid theory*". In this study, the former negatively stated item was left out, while the latter positively stated was retained. The reason for the exclusion was to avoid any confusion that might arise as learners in this study, who were mainly second-language readers, dealt with a negatively-phrased question. Furthermore, the two items adapted from Cavallo and McCall (2008) also generated an extra item because of re-wording. The result of these changes was a 4-point Likert-scale instrument with twenty-seven (27) items. The high score indicated acceptance. Possible scores for the measure, therefore, ranged from a high of 108 to a low of 27 which equated to 100% to 25% respectively.

To design the MATE, a 20-item Likert-scaled MATE instrument, developed and validated (Cronbach's alpha = 0.98) by Rutledge and Warden (1999) was adapted. This instrument has been developed to assess overall acceptance of evolution among high (secondary) school biology teachers (Rutledge and Warden, 1999), and its reliability was further determined for university students (Rutledge and Sadler, 2007) where it achieved a Cronbach alpha of 0.94. Items added to MATE by Cavallo and McCall (2008) were added to this questionnaire to "evaluate overall [learner] perceptions of evolutionary theory" (Cavallo and McCall, 2008, 526).

The questionnaires were administered soon after completion of instruction about evolution. This was only to those learners from whom consent was granted, since participation in the study was voluntary.

Data analysis

Analysing quantitative data included data reduction by use of descriptive analysis where numbers and percentages were calculated. The numerical codes useful in transforming data into numbers were already assigned when the questionnaire was designed. Analysis involved entering the data into a computer format using the Statistical package, SAS ® Version 9.3 under XP (SP3) on a desk top computer.

Analysis of MATE

The scores for each respondent were converted to percentages so that they could fit in with the five categories of acceptance found by Rutledge and Sadler (2007): Very High Acceptance = 89-100%; High Acceptance = 77-88%; Moderate Acceptance = 65-76%; Low Acceptance = 53-64%; and Very Low Acceptance = 25-52%. Associations were checked among the different characteristic variables and acceptance of evolution, and estimated from the probability value at a significance level of 0.05. If the level obtained is higher than 0.05 ($p>0.05$), the true null hypothesis is rejected.

Analysis of open-ended questions

Analysis of these questions followed a hermeneutical approach emphasizing the importance of the views of participants. As part of the interpretive process, categories were formed by grouping similar responses. The categories were further analysed inductively and coded to infer learners' beliefs about evolution and their possible worldviews. The worldviews were inferred to be 'religious' if the responses indicated religion as the view behind the response and 'scientific' if views were based on modern science. Other possible worldviews were

designated 'cultural' if they reflected knowledge that was not based on modern science or religion, and 'personal' if they reflected personal opinion not based on culture, religion or science. Other suppositions inferred from the responses related to whether evolution was regarded as valid or not, and were further subjected to inference according to possible worldviews informing them.

Findings

Biographical data

The majority (94.83%) of the learners belonged to some religion with 93.68% belonging to a Christian faith within seven denominations: Catholic (18.68%), Christian denomination not known (13.22%), Pentecostal (34.48%), Protestant (6.61%), Zionist (19.83%), AME (0.29%), Seventh-Day Adventist (0.57%. Four of these denominations (Catholic, Pentecostal, Protestant, and Zionist) were listed in the questionnaire, but AME, Seventh-Day Adventist and 'Christian' emerged from the responses of the learners who responded with the code for 'Other'. While 46.84% attended religious services more than once a week, 45.38% attended at least once a week. They attended religious services with their families more than they did alone or with friends, an indication of a strong family influence or involvement in the belief system of learners that is inclined towards religion. They were mostly from the Venda cultural or ethnic group (95.69%) with 82.01% coming from rural communities. Regarding knowledge about evolution, 47.67% learners had first heard of it from the school teacher, mostly in the preceding one to five years.

Findings from the measure of acceptance of the theory of evolution (MATE)

Table I shows the percentage responses for each of the four MATE Likert points. Some variables had missing data as emerged from the raw data presented. To offset the effect of the

Table 1.   Learners' responses to items pertaining to acceptance of evolutionary theory

Item	n	Response percentages before deletion of variables with incomplete data				Acceptance by means after deletion (*n*=117)		
		Strongly agree	Agree	Disagree	Strongly disagree	∑	x̄	SD
1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.	340	29.71	41.47	14.12	14.71	334.00	2.85	0.96
2. The theory of evolution is capable of being scientifically tested.	322	28.57	53.42	14.91	3.11	369.00	3.15	0.66
3. Modern humans are the product of evolutionary processes that have occurred over millions of years.	323	23.22	31.58	20.74	24.46	318.00	2.72	1.05
4. The theory of evolution is based on speculation.	307	12.05	25.41	44.30	18.24	271.00	2.32	0.90
5. The theory of evolution is based on valid scientific observation.	317	24.61	51.10	18.93	5.36	357.00	3.05	0.80
6. The theory of evolution is based on valid scientific testing.	315	20.95	49.52	21.59	7.94	349.00	2.98	0.82
7. Most scientists accept evolutionary theory to be a scientifically valid theory.	327	32.42	52.60	12.23	2.75	373.00	3.19	0.72
8. The available data are clear as to whether evolution actually occurs.	321	11.84	46.11	25.86	16.20	306.00	2.62	0.86
9. The age of the earth is less than 20,000 years.	322	54.66	27.95	10.56	6.83	386.00	3.30	0.94
10. There is a significant body of data that supports evolutionary theory.	322	18.63	52.80	19.57	9.01	337.00	2.88	0.83
11. Organisms exist today in essentially the same form in which they always have.	327	23.55	36.39	25.08	14.98	324.00	2.77	0.98
12. Evolution is a scientifically valid theory.	316	21.20	51.58	18.04	9.18	342.00	2.92	0.82
13. The age of the earth is at least 4 billion years.	322	19.25	32.92	26.71	21.12	294.00	2.51	1.08
14. Current evolutionary theory is the result of sound scientific research.	302	12.25	40.73	35.43	11.59	295.00	2.52	0.84
15. Current evolutionary theory is the result of sound scientific methodology.	220	10.45	43.64	38.18	7.73	297.00	2.54	0.79

Item	n	Response percentages before deletion of variables with incomplete data				Acceptance by means after deletion (n=117)		
		Strongly agree	Agree	Disagree	Strongly disagree	Σ	$\bar{x}$	SD
16. Evolutionary theory generates testable predictions with respect to the characteristics of life.	323	21.05	48.30	19.81	10.84	326.00	2.79	0.86
17. The theory of evolution can be correct since it agrees with the Biblical account of creation.	334	29.64	22.16	25.75	22.46	317.00	2.71	1.14
18. Humans exist today in essentially the same form in which they always have.	321	24.92	27.41	23.99	23.68	297.00	2.54	1.09
19. Evolutionary theory is supported by factual historical data.	323	28.79	50.15	16.41	4.64	355.00	3.03	0.76
20. Evolutionary theory is supported by laboratory data.	321	17.45	45.79	26.79	9.97	319.00	2.73	0.88
21. I believe that evolution is the best explanation for the way the world has come to exist in its present form.	325	18.77	27.38	22.77	31.08	280.00	2.39	1.11
22. Much of the scientific community accepts that evolution occurs.	324	24.07	49.69	17.90	8.33	348.00	2.97	0.89
23. The theory of evolution brings meaning to the diverse characteristics observed in living forms.	312	18.59	51.28	23.40	6.73	334.00	2.85	0.83
24. The theory of evolution brings meaning to the diverse behaviours observed in living forms.	323	18.89	43.65	26.93	10.53	313.00	2.68	0.91
25. Organisms on earth came into existence at about the same time.	324	29.94	38.58	21,30	10.19	359.00	3.07	0.93
26. Evolution is the best explanation for how the world of today has come to exist as we experience it.	320	19.69	31.56	26.25	22.50	309.00	2.64	1.01
27. Evolution is the best explanation for how the organisms of today have come to exist in their current form.	324	24.07	37.65	18.83	19.44	318.00	2.72	1.02

missing data, the affected variables were deleted, and the n-value for those with complete data was 117. Part of Table I shows the results using percentage values for the Likert points before deletion of variables with missing data. Another part presents mean-values including the standard deviation (SD) after deletion.

Using means per respondent (n=347), the average mean ($\bar{x}$) was 2.74 out of a possible maximum of 4, and this gave an acceptance rate of 68.50%. When using means after incomplete variables were deleted variables (n=117), the average mean was 2.79 giving a rate of 69.75%. Both rates fall within the moderate acceptance range of 65-76%.

Looking at the individual MATE items, the item most accepted was 9 (*The age of the earth is less than 20,000 years*) with a mean of 3.30 (SD = 0.94). Item 4 (*The theory of evolution is based on speculation*) was the least accepted, with a mean of 2.32 (SD = 0.90).

Effect of learner characteristics on acceptance of evolutionary theory

Correlations were investigated to check the effect of some of the learner characteristics on the acceptance of evolutionary theory.

The initial investigations on MATE were based on the four levels (four-point scale). These analyses yielded sparse results about which not much could be said. The four points in the Likert scale were then grouped to give two levels in order to carry out further analyses on the data. This was done by combining 'Strongly Agree' with 'Agree' to give only 'Agree', and 'Disagree' with 'Strongly Disagree' to give only 'Disagree'. The 'Strongly Agree/Agree' point became 'Agree' while the 'Disagree/Strongly Disagree' became 'Disagree' and these two were the new variables. Acceptance of the group was checked using the 2-way data and an average mean of 1.64 out of a possible maximum of 2.00 (82.00%) was achieved, indicating a high acceptance (77-88%; Rutledge and Sadler, 2007).

When using 4-way data, some items gave significant probabilities with gender: 2, 4, 15 and 25, but a result that was not significant when using 2-way data. For instance, when using 4-way data with item 25, with df=3, the Chi-square was 14.1177 and p=0.0027 and less than 0.05 indicating a significant association between gender and acceptance of this item '*Organisms on earth came into existence at about the same time*'. But when using 2-way data, with df=1, Chi-square = 3.5532 and p=0.0594 (>0.05), therefore the association is not significant.

Similarly, the variable '*From who first heard of evolution*' gave significant probability values with item 1 (p=0.0198), item 4 (p=0.0245), item 5 (p=0.0025) and item 19 (p=0.0500) with 4-way data but not with 2-way data.

Other variables checked using 2-way data were '*Age*', which showed significant associations with items 11 (p=0.0480) and 20 (p=0.0468), and '*Years since heard of evolution*' showed a significant association with three items: item 4 (p=0.0154), item 9 (p=0.0066) and item 18 (p=0.0010). Frequency of attendance at religious services did not show significant associations with acceptance of any item, so, the observed results are mainly due to chance.

In the investigation of religion, the MATE items which gave a significant probability (p<0.05) were item 3 (p=0.0363); item 5 (p=0.0491); and item 9, (p=0.0073). From these it can be concluded that there seems to be a significant association between religion and some items.

Findings from open-ended items

Results from the open-ended questions are not shown in this paper. However, Table 2 presents the results from analyses of one of the open-ended questions which required participants to give a single comment about evolution.

Table 2. Learners' comments about evolution

Categories elicited from learners' comments	Number of responses	%	Views about validity of evolution	Possible worldviews
1. Best description of origin of species arising from those that existed in the past; sharing common ancestor; and variation; very convincing; real; interesting	95	29.60	Valid and convincing	Scientific
2. Evolution is valid scientific theory; based on facts and strong evidence of changes in populations over time; natural selection; survival of the fittest	57	17.76	Valid	Scientific
3. Humans have not evolved from another species; needs more research	23	7.17	Not valid for humans	Mixed
4. Do not understand it; confused; does not occur now; make some lose faith	12	3.74	Not valid	Religious
5. Explanation of how things happen/any unclear definition	19	5.92	Unclear	Unclassifiable
6. Evolution is based on speculation; just a theory; not a fact; I do not accept it; it does not have enough evidence	12	3.74	Not valid	Personal
7. It is another religion or belief; and plays God	5	1.56	Evolution as religion	Religious
8. Anti-God; anti-Christianity; devilish; anti-Christ; anti-religion; against my beliefs	35	10.90	Against religion	Religious
9. Evolution does not exist; unreal; no proof; does not occur at all	66	19.63	Unreal, not valid	Personal
Totals	324	99.99		

Table 3. Views about evolution in terms of the validity of evolution and learners' possible worldviews

Worldviews Views	Religious	Personal	Unclassifiable	Mixed	Scientific	Totals	%
Valid					152	152	46.91
Mixed				23		23	7.10
Unclear			19			19	5.86
Not valid	52	78				130	40.12
Totals	52	78	19	23	152	324	
Percentage	16.05	24.07	5.86	7.10	46.91		99.99

Combining similar items from Table II resulted in Table 3 showing views about validity of evolution and the possible worldviews inferred from learners' responses to this question. The discussion below includes findings from other questions.

Discussion

Learners' possible worldviews

Beliefs are about what is perceived to be real and true. Truth and reality are determined for everyone by particular worldviews. These worldviews are determined by what people have been exposed to as they matured and learned more about their existence, the existence of the world and all that is in it – the whole universe. As stated by theorists, "worldviews themselves … are a response to the problem of existence and meaning of the world, and at least sketch a subliminal answer to the ultimate question of existence" (Naugle, 2002, 61). Findings from open-ended questions show that learners had beliefs ranging from religious orientations to naturalist points of departure. Similar findings were reported in other studies in South Africa, although from students at a university in the Western Cape by Lawrenz and Gray (1995, 566). They found that the students' worldviews fell along naturalism and religion continuum. In the current study, learners had a similar range of worldviews, although their responses showed more of a religious (Christian) worldview than a naturalist worldview.

Learners' acceptance of evolution

Almost all the learners in this study classified themselves as Christian and had creationist beliefs (Mpeta, 2013). Acceptance was investigated as reflected in the MATE analysis because "belief is a subjective way of knowing which can potentially blur the line between scientific knowledge and religious beliefs" (Sinatra *et al.*, 2003). Analysis found that learners in the sample 'moderately' (69.75%) accepted the theory of evolution. In support of this result it was found that close to half of the respondents (46.91%) regard evolution as valid.

This would mean that many of the learners who have religious views find the concept of evolution acceptable as a valid scientific theory. The high commitment to attendance of religious services, which could suggest a high level of religiosity of some of the learners, did not lead to lack of acceptance of evolution. These results are in line with others (Athanasiou *et al.*, 2012), who found that despite a high level of religiosity amongst the Greek students in their study, a small percentage (8.4%) agreed with the inerrancy of the scripture.

Alternatively, since it seems that learners' prior religious ideas did not influence their acceptance of evolution as negatively as would have been expected, it can be assumed that evolution is accepted because it provides these learners with a satisfactory explanation about the world. Even though results reveal a moderate acceptance, for those learners who had entrenched religious beliefs, it became difficult to accept evolution. As already found in other studies (e.g. Dagher and BouJaoude, 2005), the deeply-rooted religious beliefs of people interfere with their ability to appreciate the validity of scientific theories and concepts in an objective way. One may, therefore, reject a proposition as untrue simply because the basis for judging its validity is in an opposing worldview. Dagher and BouJaoude (2005) observed rejection of the theory of evolution on seemingly rational grounds and for reasons that demanded proof. Similarly, some learners in this study who rejected evolution did so for what they considered to be lack of evidence, referring to evolution as a 'guess', 'myth', 'not valid', 'not true' or 'not real'.

Factors which are often found to correlate positively with acceptance include an understanding of evolution (Rutledge & Warden, 1999), epistemological beliefs and thinking dispositions (Sinatra *et al.*, 2003). With two seemingly competing theories available to them, it is likely that learners felt they had to choose one to accept. Given that they were mainly exposed first to the biblical version of creation, which gave them answers regarding their existence on earth, hearing about evolution brings conflicts and doubts to some, as it seems to

present a different version of reality. They possibly evaluated the validity of evolution in terms of their own religious perspectives or worldview.

It can thus be concluded that being religious or having a religious worldview does not mean one cannot understand and accept evolution – just as much as understanding and accepting evolution does not mean one should abandon religious beliefs.

Learners' epistemological beliefs regarding evolution

As noted in the responses to the open-ended questions, some learners were so opposed to evolution that they stated not even wanting to learn about it. Some even stated that since learning about evolution, their faith was weakening. It seemed as if those learners perceived that there was a conflict between evolution and their religion. Hokayem and BouJaoude (2008, 411) mention a conflict described by Roth and Alexander (1997), in which learners thought of both religion and science as absolute forms of knowledge. With such a perception, people might feel that it is a matter of 'either/or' where one has to choose between the two, whereas viewing them differently would not demand that choice. If a learner believes in religion as absolute, then evolution may not be, hence the reason to regard it as not valid.

In this regard, learners do not seem to appreciate the tentativeness of scientific knowledge. Instead, together with the certainty they apply to their religious knowledge, they find it more acceptable because the knowledge it provides is 'truer' than that of science. Thus learners' perceptions of the epistemological status of both the concept of evolution and the practice of religion are important for making decisions about what they support.

Learners' beliefs and their influence on learning about evolution

The expectation was that these learners would find difficulties in learning about evolution because of the perception they held that evolution contradicts the theory of creation as related in the Book of Genesis, which they believe to be true. Learners were influenced in three main

ways: 'positively' where they enjoyed learning evolution and were motivated to learn more, 'negatively' where they felt uncomfortable or even felt forced to learn against their beliefs, and some experienced 'no influence' and felt that they learned evolution in the same way they learned other Life Sciences topics. Some did not know what to believe, while others felt that their teacher was trying to persuade them to abandon their Christian beliefs and to accept evolution.

Despite having creationist beliefs, some learners found reasons to want to learn more and understand about evolution. For some, understanding meant passing in the examinations. For others, understanding would enable them to prove that evolution was false, since creation as narrated in the Bible was the correct explanation of the origin and diversity of species. Nevertheless, these learners demonstrated a strong will to learn. Even those with a negative attitude toward evolution did not allow that to be an impediment to learning, an indication that learner motivation was crucial to learning than perhaps, the influence by personal beliefs.

Others have shown that, rather than learning being controlled exclusively by external factors such as the nature of the content or instruction, learners play a significant role in choosing whether to consider alternative points of view (Sinatra *et al*., 2003, 511). Even if learners' motivation to learn is encouraged by the teacher or other external factors such as examinations, it is the learner who in the end makes the decision to learn and who follows that decision through by acting accordingly.

Learners' knowledge about evolution was not tested in this study. However, given that they felt they understood something about evolution indicates that knowing about something does not mean that one automatically accepts or believes in it. Similar observations have been made (Brewer & Chin, 1991 in Sinatra *et al*., 2003) where students understood new theories

in the domains of special relativity and quantum mechanics "but failed to accept them" (*ibid*., 513).

Some misconceptions were identified, though. For instance, some learners considered that individual organisms would evolve in their lifetimes in response to environmental discomforts. It is true that environment affects evolution, as described by Darwin and Wallace in their theories. Environment also affects development of individual organisms. The idea from the learners, though, has an element of environmental determinism, where the environment is thought to set limits to the development of organisms, determining how they develop. This idea suggests that individuals evolve out of choice, an idea resembling Lamarckism. It also suggests understanding of evolution of individual life forms at or below species level, but is silent on macroevolution, where a species can evolve into another or others. Recognizing only the micro elements of evolution can lead to disapproval of macro elements and the denial that species can evolve into others, such as denying that humans and apes have evolved from a common ancestor that was of a different species.

Educational implications

This study has perhaps highlighted some of the challenges that could be facing the teaching of evolution in South African secondary schools. As reflected in the attitudes expressed by learners in this research, religious beliefs bring the theistic worldview to the classroom where the content being taught bears a naturalistic worldview. Learners' comments were indicative of tensions that are experienced by those who have deeply-rooted religious beliefs.

A surprise finding was that only one participant (0.29%) declared belonging to an African religion. There seems to be a stronger uptake of Christianity in this group of learners. The tension that was observed in this study emanated not from the African traditional or indigenous beliefs but mainly from Christian beliefs.

With regard to learning, the influence of learners' beliefs manifested itself in the refusal by some learners to accept the notion of evolution, implying resilience of such beliefs and a possibility that they are regarded as rational by those who hold them. When learners decided to leave their beliefs aside when learning about evolution, they were perhaps consciously or unconsciously avoiding a situation where they would use their beliefs to evaluate the validity of evolution. But ignoring such beliefs in evolution classes may alienate learners completely from a unifying biological concept. It has been suggested that educators should consider religious worldviews if some students are to better understand some science's key conclusions such as the theory of evolution (Reiss, 2009). It may, therefore, be worthwhile to investigate how religious beliefs/worldviews may be used to scaffold learning of evolution, especially for learners experiencing conflicts. For instance, identifying any possible points of convergence between their religious views and evolution may generate a scaffold towards accepting evolution. Enhancing the nature of science in the teaching of evolution may also enable the learners to think more critically when evaluating evidence about evolution.

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