Creationist and evolutionist views of South African teachers with different religious affiliations

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Concerns have been raised in the scientific community that many teachers do not accept evolution as a scientific, testable phenomenon, and this is evident in their teaching. The non-acceptance of evolution theory is often heavily influenced by religious groups that endeavour to eliminate evolution from the curriculum. In South Africa, the inclusion of evolution in the curriculum is a recent event. This study focused on teachers' views of evolution in relation to their religious affiliations. A questionnaire was developed and was validated by the Biohead–Citizen Project, and was then administered to more than 300 South African teachers and student teachers. Equal numbers of pre-service and in-service teachers were sampled. The groups included equal numbers of biology, English, and generalist teachers at primary school level. The results showed differences between teachers from different religions with regard to their views of evolution. Among teachers who identified as agnostic or atheist, 17% held creationist views. Among teachers who identified as Protestant, other Christian, or Muslim, 70% held creationist views. This study also examined, for the first time, the views of teachers belonging to religions not included in previous research. Of these, only 25% of Hindus held creationist views. Fewer adherents of African Independent Churches held creationist views compared with teachers from traditional Protestant denominations; for example, only 30% of Zionist followers and 40% of Shembe followers held creationist views. This study adds important knowledge by including the views of teachers from religions not previously researched.

Introduction

On 21 June 2006, the Inter-Academy Panel (IAP[1]),a global network of 68 science academies, published a joint statement on the teaching of evolution. The statement read as follows:

> *We, the undersigned Academies of Sciences, have learned that in various parts of the world, within science courses taught in certain public systems of education, scientific evidence, data, and testable theories about the origins and evolution of life on Earth are being concealed, denied, or confused with theories not testable by science. (p. 1)*

This statement acknowledged that several student teachers or qualified teachers did not accept evolution as a scientific, testable phenomenon, and this bias was evident in their teaching. This state of affairs was initially reported on by a number of authors[2-4] in the USA, where the teaching of evolution is still a contentious issue in many communities.

Research has shown that in several countries, differences exist with regard to the inclusion of evolution in the curriculum.[5-8] Countries such as Italy and Germany have experienced controversy over the teaching of evolution.[9] Some controversy also exists in the United Kingdom regarding the teaching of evolution.[10] Although the level of acceptance of evolution theory is generally higher in Western Europe than in the USA, special creationist ideas are widespread.[11] More Protestants who belong to non-mainstream denominations, as well as conservative Muslims, accept the theory of special creation compared with any other religious groups. This means they believe God created all living things and that no changes have occurred since creation[12,13] (see Table 2 for percentages of people who hold this belief).

A comprehensive body of research points to the influence of religion on the acceptance of evolutionary theory. A study reported by Martin[14], whilst not conducted with teachers, provides valuable insight into the views of the public based on the views of governing bodies of various Christian denominations. Martin's research showed that more people in the USA accept evolution theory than those who reject it.[14] However, many members of special creationist groups – such as Pentecostal Protestants – find no compatibility between their faith and evolution.[14]

Several scholars, namely BouJaoude, Asghar, Wiles, Jaber, Sarieddine, and Alters[15] as well as Clément[16] report that in Lebanon, Christian teachers and Muslim Druze teachers are more inclined to accept the theory of evolution than other Muslim groups. The same authors report that some individuals from Muslim groups who do accept the theory have reinterpreted it to exclude human evolution. Clément[16] showed that Muslim teachers' views of evolution differed significantly from one country to another. In Burkina Faso, Muslim (Sunni) teachers accept evolution more readily than their Protestant colleagues. In Lebanon, there is no significant difference between Christian, Druze, and Shiite teachers' views of evolution, with only their Sunni colleagues' views being a little more creationist.

Asghar[17] conducted a study to assess the evolutionary views of Muslim science teachers from diverse contexts such as Canada and Pakistan. Her study showed that most teachers were prepared to accept the evolution of living organisms, apart from human beings. They felt that human evolution contradicted their Islamic beliefs. BouJaoude, Wiles, Asghar, and Alters[18] conducted a similar study with learners from three different Muslim groups in Lebanon and Egypt. The study showed that the religious beliefs of Sunni and Shiite Muslim learners from both countries influenced their views of evolution.

In the South African context, the teaching of evolution in schools emerged as an issue with the implementation of a new Life Sciences curriculum, spelled out in the National Curriculum Statement.[19] According to Lever[20], the new curriculum endeavoured to include content that had been omitted because it was seen as being alien to the ethos of Christian National Education, which had underpinned the previous curriculum. The theory of biological evolution was one such topic.[20] Most teachers of biology had obtained their qualifications at colleges of education where evolution was not taught as an integral part of biology. The exception was a small number of colleges that fell under the administration of the various provincial administrations rather than the Department of Bantu Education. According to Sanders and Ngxola, even teachers who had obtained bachelor degrees in the biological sciences agreed with their less-qualified counterparts that they had inadequate knowledge of evolution or how to teach the subject.[21] This state of affairs has sparked a number of research projects[22,23] to assess how teachers view evolution theory, and their attitudes towards the teaching of the subject.

In the current South African curriculum,[24] evolution constitutes 22% of the Grade 12 Life Sciences curriculum in terms of marks allocated and teaching time. This places a great responsibility on teachers to teach this section competently, to enable their learners to pass the exit-level matriculation examinations at the end of Grade 12. However, many South African teachers do not accept the theory of evolution[22,23] and these teachers initially felt a sense of inner conflict. They were expected to teach a topic they had not studied in their initial training, had no experience of teaching, and about which they held negative views.[25-27]

The South African education system is centralised and prescribes what teachers are required to teach. It is dominated by a national exit-level examination, the National Senior Certificate, which determines access to tertiary education. The highly prescriptive nature of the curriculum and external assessment make it impossible for a teacher to omit the subject of evolution at Grade 12 level. At professional development workshops organised to help teachers improve their knowledge of evolution, some teachers voiced their concerns about teaching evolution.[20] As recently as 2013, Keke[28] found that teachers still listed evolution among the topics they found most difficult to teach.

The relatively recent introduction of evolution in the Life Science curriculum in South Africa, and the identified teacher concerns mentioned above, have spawned a number of research endeavours. Kyriacou, De Beer and Ramnarain[29] identified several problems related to currently-employed teachers' knowledge of evolution. One of these was objections raised by some fundamentalist religious groups. Similarly, a study by Mpeta[27] showed that religion played an important role in both learners' and teachers' views on evolution. Furthermore, Abrie[25] found that student teachers who were more religiously observant were more opposed to teaching evolution than their less observant peers.

Pillay's[30] research included both Christian and Muslim teachers. Although lack of content knowledge played an important role in their opposition to evolutionary theory, all the Muslim teachers and most of the Christian teachers were of the view that their religious beliefs contradicted the theory of evolution. The work of Yalvac[31] showed that Muslim teachers who were interviewed saw themselves as creationists. In that study, many Christian teachers surveyed were also opposed to evolutionary theory. Naidoo[32] argues that Hindu teachers and learners have no problem with evolutionary ideas because Hinduism has no creation story depicting creation as a once-off event.

The Biohead–Citizen research project[33] is an international study that has obtained data on teachers' conceptions across numerous countries. Initially, eighteen countries participated in the project and subsequently the Biohead–Citizen questionnaire has been administered in a further twelve countries. Data obtained from this project show that countries sometimes show different trends in teachers' acceptance of evolutionary theory. For instance, Clément and Quessada[34] found that the percentage of teachers holding creationist views differed from country to country, even for teachers of the same religious group. Fundamentalist creationist conceptions ranged from 0% to 62% among Roman Catholic teachers, and from 2% to 76% among Protestant teachers in various countries. Within each of 26 countries studied, no significant difference existed among the various religions with regard to the percentage of teachers who held fundamentalist creationist views.[12,34,35] However, there are exceptions. In Brazil, Protestant teachers hold more creationist beliefs than those of their colleagues in other religions.[36] In Lebanon, the ideas of Sunni Muslim teachers are a little more creationist than their colleagues'. In Burkina Faso, the views of Muslims are less creationist than those of Protestants. In South Korea, the views of Protestant teachers are more creationist than their colleagues who are mainly agnostic, atheist or Buddhist.[37]

These findings prompted us to administer the Biohead–Citizen questionnaire in South Africa. South Africa provides an interesting case study because the country has diverse religions, including Christianity, Islam, Hinduism, Buddhism, and African traditional churches or beliefs.[38] Census 2001, the last time data on religious affiliation was collected in South Africa, identified four categories of Christian churches: mainstream (Roman Catholic, Anglican, Methodist, Presbyterian, Lutheran and Congregational), African Independent Churches (Zionist, Shembe and Ethiopian-type), 'other Christians' (not defined), and 'Pentecostal / charismatic' (not defined).[38]

Roman Catholic and mainstream Protestant churches have a long history in most countries of the world. The African Independent Churches (AICs) have developed in Africa as offshoots of Protestant-type Christian churches.[38] African traditional beliefs comprise a variety of belief systems that are inherently African, but most adherents also hold some Christian beliefs. Because AICs are unique to Africa, they are separate from mainstream Protestant churches. In Census 2001, almost 32% of South Africans belonged to one of the AICs, with the Zion Christian Church (ZCC) being the largest.[39] The ZCC has its origins in the Catholic Apostolic Church and is regarded as a form of African Pentecostalism.[40] The oldest AIC in Africa is the Nazareth Baptist Church, also known as Ibandla namaNazaretha or Shembe, after its founder. Estimates of its following vary from about 250 000 people[38] to 4.5 million people.[41] Although the church has its roots in Christianity, it is a mixture of Zulu traditional beliefs and Christianity. Members believe in the Holy Trinity but observe the Jewish Sabbath, and hold the belief in an African Messiah.[41] Most followers of Shembe live in the province of KwaZulu-Natal.

Mainstream Protestant churches in many countries have accepted the theory of evolution. Charismatic Protestant churches, including Pentecostal and the Full Gospel Church, are much more literal in their interpretation of biblical texts.[15]

Table 1 shows our reasoning for the categories we defined in the present study. In future studies, the question (P13, shown in the Methodology section of this paper) eliciting information about religion should be reworded. Our results showed that some members of Pentecostal or charismatic churches may have identified themselves as Protestant, but others wrote the name of the church to which they belonged. Thus eight members of the Full Gospel Church were identified separately from the Protestant group. Table 1 gives a brief description of the religious groupings used in this study.

One of the aims of the Biohead–Citizen Project was to compare the views about evolution among teachers of different religions.[48,49] Such information could assist in structuring teacher education programmes to address issues such as teachers who are strongly opposed to accepting evolution as an important topic in the teaching of biology. Similarly, the purpose of our study was to investigate the relationship between beliefs about evolution and religious affiliation among South African teachers. The question that drove our research was: *What views do South African teachers from different religious affiliations hold with regard to evolution?*

Conceptual framework

Various theoretical and conceptual frameworks have been used to frame studies relating to issues surrounding the teaching and learning of evolution, as well as the acceptance of evolutionary theory. The 'stages of concern' theory developed by Fuller[50] and Hall and Loucks[51] has been helpful in designing appropriate professional development courses and has been applied particularly for courses in evolution.[21] Scott's[52] creation–evolution continuum illustrates the positions people may hold in the evolution–creation controversy. Table 2 provides a summary of Scott's model.

Table 1: A brief description of belief systems of religious affiliations

Code	Belief system	Description
AGN	Agnostic Atheist	Agnostics believe it is not possible to say with certainty whether or not God exists.[42] Atheists deny the existence of a deity.[42]
CAT	Roman Catholic	The main teachings of the Roman Catholic church are God's objective existence, and acknowledgement of Him as creator of heaven and earth. The church does not have an official position on whether various life forms developed instantaneously (creationism), or over the course of time (evolution). However, if they did develop slowly, they did so under the impetus and guidance of God and their ultimate creation must be ascribed to God.[43]
PRO	Protestant	Protestants believe in God as the creator of the universe and all in it. Beliefs about how this creation occurred vary. Some mainstream Protestants have theistic evolutionist beliefs, whereas others interpret the Bible more literally. Officially these churches accept evolution as a possible explanation for the diversity of life.[44]
ELS CHR	Other Christian churches (mostly Pentecostal)	Pentecostalism is a renewal movement within Protestant Christianity that emphasises personal and direct experience of God through baptism in the Holy Spirit. This group believes in the inerrancy of the Bible, and therefore interprets biblical texts literally.[44] This means all things were created in six days and no changes have occurred since then (creationist view).
FULL	Full Gospel Church of God	The Full Gospel Movement is associated with Pentecostalism and Charismatic Christianity. While their religious doctrines are different, they hold similar views to that of the Pentecostal churches with regard to the inerrancy of the Bible.[44]
MUS	Muslim (Sunni)	Sunni Islam is a denomination of Islam that is sometimes referred to as 'orthodox' Islam. Sunni Muslims regard Allah as the only God and creator of all.[45]
HIND	Hindu	Hinduism is not predominantly earth-centred, and puts much emphasis on other planes of existence. There is no one simple account of creation, and there are many detailed and inter-related stories.[46]
ZIO	Zion Christian Church	The ZCC fuses African traditions and values with Christian faith. The bishop and ministers of ZCC preach the Gospel of Jesus Christ as laid out in the Bible.[41] They have no specific doctrine regarding creation of the universe.
SHEMBE	Shembe and other African Religions	The church of the ama-Nazarites, also generally known as the Nazareth Baptist Church, was founded by Isaiah Shembe. His theology was based on his conviction that he was the mouthpiece and instrument of Jehovah. This religion has no pertinent doctrine regarding creation.[47]

Table 2: An adaptation of Scott's creation–evolution continuum

YOUNG EARTH	Flat Earth Geocentrism Young Earth Creationism	Special Creation Creation–evolution continuum Evolution
OLD EARTH	Gap Day-age Progressive Theistic evolution Materialist evolution Intelligent design	

Source: Modified from a diagram by Scott[52]

According to Scott[52], Young Earth creationists are biblical literalists who believe, based on calculations from characters and events named in the Bible, that the Earth came into existence only a few thousand years ago. These include the Flat-Earthers, who believe the Earth is a round disc, and the geocentrists, who believe the Earth is a sphere but do not accept the findings of modern physics and geology pertaining to the age of the Earth. Because this group interprets the creation story in their religious books literally, they deny biological descent with modification (i.e. evolution).

Scott[52] refers to several groups collectively as Old Earth creationists, as they accept that the earth is ancient. The Gap Theory and Day-Age creationists have various explanations of biblical events to attempt to reconcile science and religion. Most Old Earth creationists hold some view of progressive creationism. This view blends special creationism with aspects of science. It accepts speciation but rejects macro-evolution. Intelligent design is a branch of progressive creationism that believes the study of living organisms produces evidence of God's creation. They believe complex organisms could not have evolved by chance, and must have been designed by an 'intelligent being' – that is, God. Adherents of 'intelligent design' are found across the continuum of creationist beliefs.

There is a sharp division between Young Earth creationists and Old Earth creationists. However, the division between the Old Earth creationist subgroups is less clear, as there is a gradual increase in the extent to which science influences the beliefs of these groups. At one end of the continuum are theistic evolutionists, who accept macro-evolution but believe that it is managed by a divine being. Most mainstream churches accept this view. Materialist evolutionists, by contrast, hold a non-religious view and accept only scientific explanations for life and its diversity.[52]

This continuum is useful in classifying people from the Christian faith, and to a lesser extent other monotheistic religions that originated in the Middle East. But it does not accommodate the views of people from other religions, many of which have no creation story as a central tenet of their religion. Because we wanted to include other religions too, we needed a different conceptual framework. The Biohead–Citizen Project uses three concepts: *evolutionist*, *creationist*, and simultaneously *creationist and evolutionist*. As the famous evolutionist Dobzhansky[53(p.127)] claimed in 1973*:* 'I am a creationist and an evolutionist. Evolution is God's, or Nature's, method of Creation.' This category is not far from the theistic evolution category defined by Scott[52], and does not conflict with teaching biological evolution – whereas the others forms of creationist conceptions do.

Methodology

The Biohead–Citizen Project was funded by the European Commission, and adheres to the ethical requirements of the Commission (number CICT-CT-2004-506015). However, the South African part of the project was funded by the South African authors of this paper. A questionnaire

developed and validated by the Biohead–Citizen research project[33] was used for this study. The questionnaire contained 144 questions covering a number of topics; 15 questions were dedicated to evolution and 17 questions related to personal information (gender, age, level of education, and religion or religious opinions).

A few questions followed a multiple-choice format. Others used a Likert-type scale, with four responses (ranging from 'I agree' to 'I disagree') to a statement. Each response was scored on a scale of 1 to 4. Questions on evolution were designed to elicit answers that indicated whether a teacher's conceptions were towards the creationist end of the continuum or towards the opposite evolutionist pole. Teachers could also choose answers that could be classified as simultaneously evolutionist and creationist.

For example, items B42 to B48 asked respondents to indicate the importance of a number of factors in species evolution. Factor B42 is 'Chance', and teachers were asked to rank its importance from 'great importance', 'some importance', 'little importance' to 'no importance at all'. An answer of 'great importance' in this case would be classified as strongly evolutionist, while 'no importance at all' would be classified as strongly creationist. In the same section, factor B48 is 'God'. Here, an answer of 'great importance' would be strongly creationist, and 'no importance at all' strongly evolutionist. In both cases, an answer of 'some importance' shows a degree of ambivalence that classifies the answer as simultaneously evolutionist and creationist. An answer of 'little importance' tends towards one end of the continuum, and would be classified as evolutionist or creationist depending on the factor.

Some questions were adapted to suit the South African context. For instance, respondents were asked to identify their religious affiliation, where the religions listed were those commonly found in South Africa. These are illustrated in the following question:

P13. **Are you?** (tick only **ONE** box):

☐ Agnostic/Atheist

Christian: ☐ *Catholic* ☐ *Protestant* ☐ *Zionist* ☐ *Shembe*

☐ *Other (specify):* _____

Moslem: ☐ *Sunnite* ☐ *Shiite* ☐ *Other (specify):* _____

☐ Jewish

☐ Hindu

☐ Buddhist

☐ Other religion/belief (specify): _____

☐ I don't want to answer

Our sample was limited to the province of KwaZulu-Natal, South Africa, as the first step of a possible larger project. Potential respondents were assured that their participation was voluntary, and all who agreed to participate were assured of anonymity. The sampling method was the same as that used in previous studies,[33] to allow comparisons of the effect of religious affiliation, teaching specialisation and experience on teachers' positions on the continuum between evolutionism and creationism.

A total of 336 teachers filled out the questionnaire, with their expertise or training being as follows:

- 53 in-service teachers of biology (secondary schools)
- 60 pre-service teachers of biology (final year of their training)
- 65 in-service generalist teachers in primary schools
- 58 pre-service generalist primary school student teachers (final year of their training)
- 49 in-service teachers of English (secondary schools)
- 51 pre-service student teachers of English (final year of their training).

The above list represents our expected 'hierarchy' of knowledge of evolution, from the greatest to the least.

Respondents were contacted in various ways, all of which were a form of convenience sampling. These forms of contact were:

- Distribution of questionnaires at a provincial workshop, where the workshop facilitators agreed to allow additional time after the workshop to complete the questionnaire.
- Distribution to selected biology teachers, where the researchers oversaw the completion of the questionnaires after school hours.
- Distribution to students at two tertiary institutions: a private college of education, and the School of Education at a university.

The data were collected in 2013 in KwaZulu-Natal, where the South African researchers are based, under the supervision of the South African participants in the Biohead–Citizen Project study. Answers were coded exactly as described for the BioHead-Citizen Project.[33] There were no incomplete questionnaires.

Statistical analysis was conducted by the French participant in conjunction with a qualified statistician. The software R (R Development Core Team[54]) for multivariate analyses was used for this purpose. We conducted between-class analyses (Dolédec and Chessel[55]) to discriminate between teachers' groups as defined by the main parameters (gender, age, level of education, religion, and teaching experience).

A Monte Carlo permutation test (Romesburg[56]) implemented in the ade4 library of R was then used to see if the difference between the groups was or was not statistically significant. Multivariate tests were used to test for differences in scores on any of the questions, according to the main parameters listed in the previous paragraph. Scores for the 15 questions related to evolution were analysed. We also ran a principal component analysis of orthogonal instrumental variables (PCAOIV), as described by Sabatier et al.[57], to analyse if the effect of one parameter remained significant after suppressing another significant effect. Here we tested the independence of the effect of 'religious affiliation' from the characteristics of the six groups of teaching expertise, identified as follows:

- in-service biology
- pre-service biology
- in-service English
- pre-service English
- in-service primary generalists
- pre-service primary generalists.

As shown in previous studies,[58,59] these kinds of multivariate analyses are appropriate for the data collected with the Biohead–Citizen questionnaire.

Results

Table 3 shows the religions of respondents and the number of respondents in each religious group, as well as the codes used in the statistical analysis. Many respondents wrote the name of their church rather than ticking a box provided. The churches were then grouped using the categories established for Census 2001.[38]

Full Gospel was not included as a choice in Question P13, but was specifically written in by eight respondents. A separate code was therefore created to accommodate this denomination.

Two between-class analyses were performed, to test whether significant differences emerged that could distinguish between the groups, based on their responses to all 15 questions. The outcomes we examined were knowledge and beliefs about evolution among the tested groups:

1. The between-class analysis differentiated between the six sample groups (in-service or pre-service; biology, English or primary generalist). As expected, biology teachers (both pre and in-service) had significantly better knowledge about some processes of evolution, and held slightly more evolutionist views, than any of their colleagues.
2. The most marked differences identified by between-class analysis were related to the teachers' religious beliefs, as shown in Figure 1.

Table 3: Numbers of teachers in each religious group identified in the sample

Code	Religious affiliation or belief system	Number of participants	Percentage of sample
AGN	Agnostic and atheist	17	5.1
CAT	Roman Catholic	65	19.3
PRO	Protestant	97	28.9
FULL	Full Gospel Church of God	8	2.4
ELS CHR	Other Christian religions, mostly Pentecostal	15	4.5
MUS	Muslim (Sunni)	19	5.7
HIN	Hindu	36	10.7
ZIO	Zionist	30	8.9
SHEMBE	Shembe and other African religions	20	6.0
OTHER	Other	2 (1 Buddhist)	0.6
NR	No answer	27	8.0
	TOTAL	336	

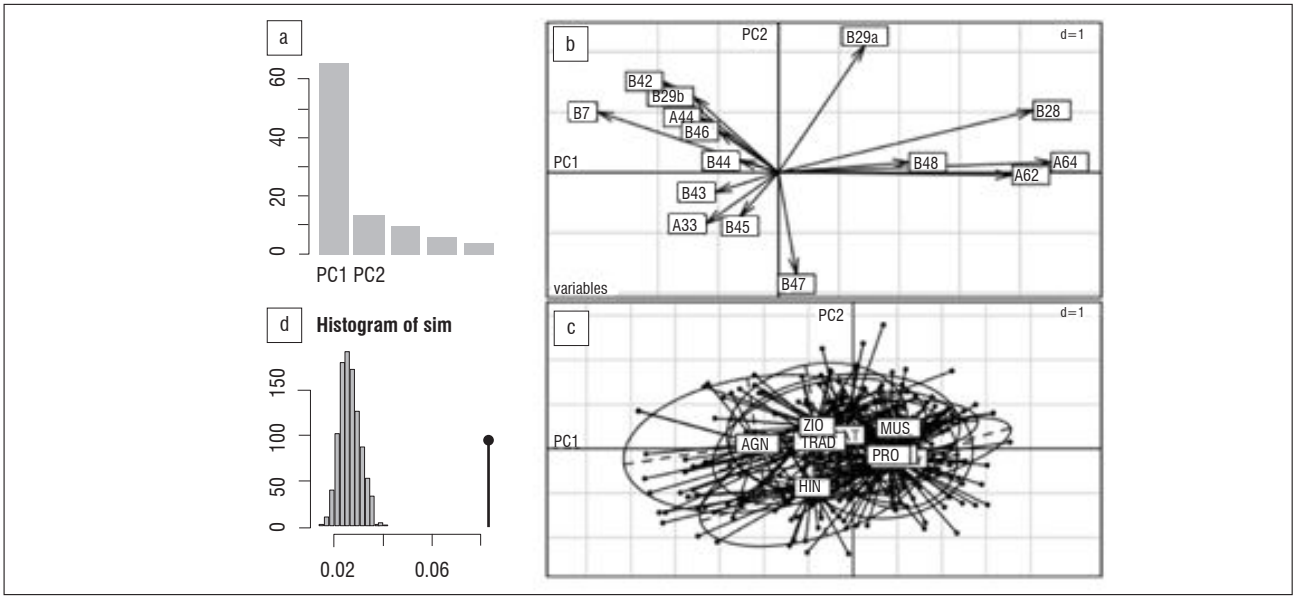

Figure 1: Between-class analysis differentiating the groups of teachers (according to religious affiliation) based on the 15 questions related to evolution. (a) Contribution of each principal component to the total variance: the first principal component (PC1) accounts for more than 65% of the total variance; the second (PC2) accounts for 12%. Subsequent components are considered to be background noise. (b) Loading of answers to the 15 questions (evolution variables) on PC1 (horizontal axis) and PC2 (vertical axis). The length of each arrow indicates the loading of each question on PC1 and PC2. (c) Each point summarises a teacher's answers to the 15 questions, and is related to the group centroid for each religious affiliation. Each ellipse encompasses two-thirds of the teachers in a religious group. (Figure 2 presents these results in simplified and enlarged format.). (d) Histogram of simulations: Results of a randomisation test (Monte Carlo type) generated from 1000 iterations, randomly assigning a religious affiliation to each teacher. The observed variance (to the right) is distinct from random, showing that the results in Figure 1c) are not random ($p<0.01$).

Figure 1a shows that the first principal component (PC1) explains over 65% of the total variance. The second component (PC2) accounted for 12%, meaning these two components together accounted for most of the variance (77%). It was therefore not necessary to investigate further components.

Figure 1b shows the contribution of each of the 15 questions on evolution to PC1 and PC2. Five questions – those with the longest arrows – have the highest loading on PC1 (B64, A62, B28, and to a lesser extent B48 and B7). All these questions are related to the continuum between evolutionism and creationism. Thus PC1 differentiates among the respondents' views in terms of their position on that continuum, with the most strongly creationist answers to the right of the axis and the most strongly evolutionist to the left. Figure 1c shows the diversity of teachers' views within each religious affiliation. The ellipses encompassing two-thirds of teachers from each religious affiliation overlap. Nevertheless, their centroids are distributed along the horizontal axis, which is easier to see in Figure 2 (an enlargement of Figure 1c).

Figure 1d shows, from a Monte Carlo randomisation test, that answers to questions relating to evolution differed significantly among the religious groups identified in this study ($p<0.01$). Nevertheless, it is *a priori* possible that the observed significant differences among religious affiliations could be a result of the differences in teachers'

views depending on their specialisation (biology, English or generalist primary school). We mentioned earlier the significant differences linked to specialisation.

To test the possibility that the differences shown in Figures 1 and 2 were influenced by specialisation, we conducted a principal component analysis of orthogonal instrumental variables (PCAOIV; Sabatier et al.[57]). The effect of the six groups (in-service or pre-service, plus subject speciality) was suppressed so that we could investigate other influences. A subsequent between-class analysis, followed by a randomisation test, showed a persistent significant difference among the religious affiliations ($p<0.01$), with the same order along the horizontal axis (PC1) as shown in Figures 1 and 2. Consequently, the differences shown in Figures 1 and 2 are not merely artefacts from different levels of training in biology among the teachers.

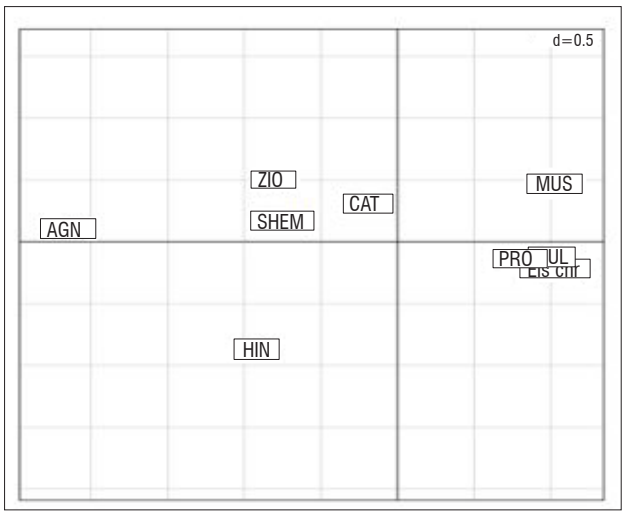

Figure 2: Group centroids characterising the positions of religious affiliations along PC1 (horizontal axis) and PC2 (vertical axis).

Figure 2 shows the group centroids for the religious affiliations in relation to PC1 and PC2. Protestant (PRO), Full Gospel (FUL) and Other Christian (ELS CHR) categories overlap entirely. The most strongly evolutionist answers were given by agnostic or atheist (AGN) teachers, and the most strongly creationist answers by Muslim (MUS), Protestant (PRO), Full Gospel (FUL) and Other Christian (Els Chr) groups. The Zionist (ZIO), Shembe (SHEM), Hindu (HIN), and to a lesser extent Roman Catholic (CAT) teachers held views that were more evolutionist than creationist.

The main finding of the PCA was that the sampled teachers could be positioned according to their religious affiliation along a continuum, from extreme evolutionism to extreme creationism. At one end were those holding evolutionist views (agnostic or atheist), in the middle was a group that held mixed evolutionist and creationist views (Zionist, Shembe, Hindu and Roman Catholic), and at the other end was a group that held strong creationist views (Muslim, Protestant, Full Gospel and Other Christian). The analysis then illustrated the responses of the groups by graphing their responses to the three questions that achieved the highest loadings on PC1 (namely questions A64, B28 and A62).

Because only eight respondents identified 'Full Gospel' as their religious affiliation, they were incorporated into 'Other Christian' (Els Chr) for further analyses. However, this merging of Full Gospel with Other Christian was only done after the PCA, which showed a complete overlap between Full Gospel with Other Christian. Hence, 'Other Christian' gives insight into the views of 23 adherents of mainly Pentecostal or charismatic churches. Figures 3, 4 and 5 show the frequency distribution for answers given by teachers who indicated their religious affiliation ($n=309$).

Question A64 is about the origin of life. Four statements are presented; the first and second statements are strongly evolutionist (the first being most dogmatic), and the fourth statement is strongly creationist. Statement three is both evolutionist and creationist, acknowledging the control of evolution by a creator (theistic evolution). The question is:

> **A64**. Which of the following four statements do you agree with the most? (tick only ONE answer).
>
> ☐ It is certain that the origin of life resulted from natural phenomena.
>
> ☐ The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.
>
> ☐ The origin of life may be explained by natural phenomena that are governed by God.
>
> ☐ It is certain that God created life.

Figure 3 lists the groups, based on religious affiliation, ranked from most evolutionist at the top (agnostic or atheist) to most creationist (Muslim and Other Christian) at the bottom. Approximately 70% to 75% of Protestants, Muslims and Other Christians were certain that God created life. This proportion was about 50% among Roman Catholics, and dropped to less than 20% for the atheist and agnostic group. A large proportion of every group except atheists and agnostics selected the third answer, which allows for evolution under the control of God.

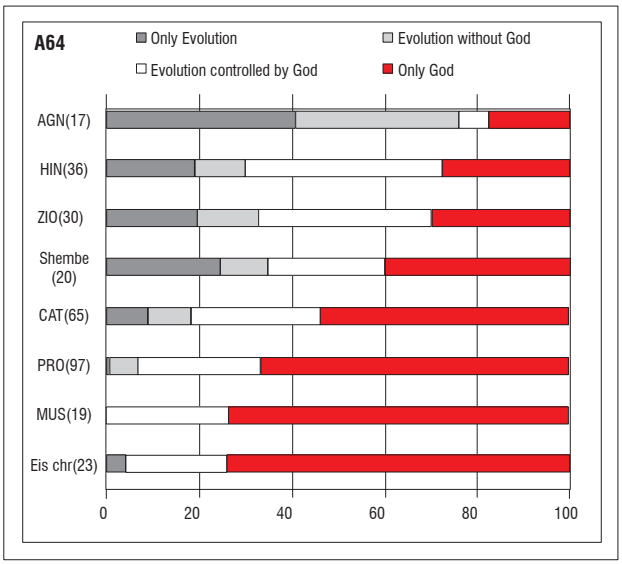

Figure 3: Percentage of teachers (grouped by religious affiliation) who selected creationist (red), evolutionist (black and grey), or mixed creationist and evolutionist (white) answers to question A64 on the origin of life.

Only the atheist and agnostic (AGN) group had a majority of responses that dispensed with the need for a creator entirely, with almost 80% of that group selecting the first or second option. However, three teachers (17%) in the AGN group selected the fourth option, that God created life. Because atheists reject the idea of God, we may assume these three teachers were agnostic. About 30% of Hindu and Zionist respondents, and 40% of Shembe adherents, chose the strongly creationist answer (the fourth statement). The Muslim group presented the most strongly creationist response, with no respondent selecting answers that excluded God.

The third option, compatible with a theistic evolution perspective, was least attractive to the AGN group, with only one AGN respondent selecting that option. It was the most popular option for Hindu and Zionist respondents (36.7% and 41.7%, respectively), and was chosen by more than 25% of all remaining groups except Other Christian, of whom 21.7% chose this option.

Question B28 was about the origins of humankind. As in question A64, four statements are presented, the first two being most strongly evolutionist and the last most strongly creationist:

B28. Which of the following four statements do you agree with most? Select ONLY one sentence:

- ☐ It is certain that the origin of the humankind results from evolutionary processes.
- ☐ Human origin can be explained by evolutionary processes without considering the hypothesis that God created humankind.
- ☐ Human origin can be explained by evolutionary processes that are governed by God.
- ☐ It is certain that God created humankind

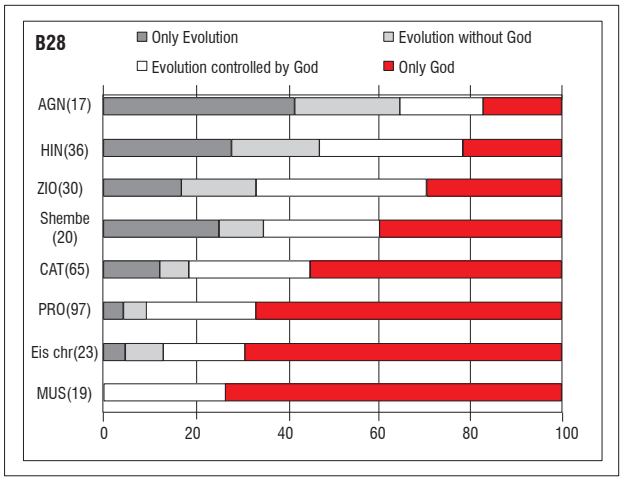

Figure 4: Percentage of teachers (grouped by religious affiliation) who selected creationist (red), evolutionist (black and grey), or mixed creationist and evolutionist (white) answers to question B28 on the origin of humankind.

Figure 4 lists the groups ranked from most evolutionist at the top (agnostic or atheist) to most creationist at the bottom (Muslim). Approximately 70% to 75% of Protestants, Muslims and Other Christians were certain that God created humankind. This proportion was about 55% among Roman Catholics, and dropped to between 40% and 20% for Shembe, Zionist and Hindu, and to less than 20% of the AGN group. Once again, between 17.4% and 36.7% of all respondents showed theistic evolution beliefs by selecting the third answer, which allows for the controlling hand of God in the natural process of human evolution.

For Question B28, agnostic or atheist teachers were the least likely to select the third answer (17.6%), with the Other Christian group being second least likely (36.7%). About 25% of each of the remaining groups chose the third option. No Muslims, and only 10% to 15% of Protestants and Other Christians, selected purely evolutionist answers – namely that humans arose by natural evolution without the intervention of God. Nearly 50% of Hindus selected evolutionist answers (first and second options), in contrast to the 30% of Hindus who selected evolutionist answers to Question A64. The pattern of answers for Zionist and Shembe adherents was similar to that for question A64, with over 30% of each group adopting an evolutionist position.

Question A62 makes another kind of statement concerning the origin of humankind. Respondents are asked to select three terms that they believe are most strongly related to the origins of humankind. Coding of the answers (0 to 3) was based on how many terms chosen were associated with creation. The first, third and fifth terms are creationist, whereas the second, fourth and sixth terms are evolutionist:

A62. In the list below, tick the THREE expressions that you think are the most strongly associated with the origins of humankind.

- ☐ Adam and Eve
- ☐ Australopithecus
- ☐ Creation
- ☐ Evolution
- ☐ God
- ☐ Natural selection

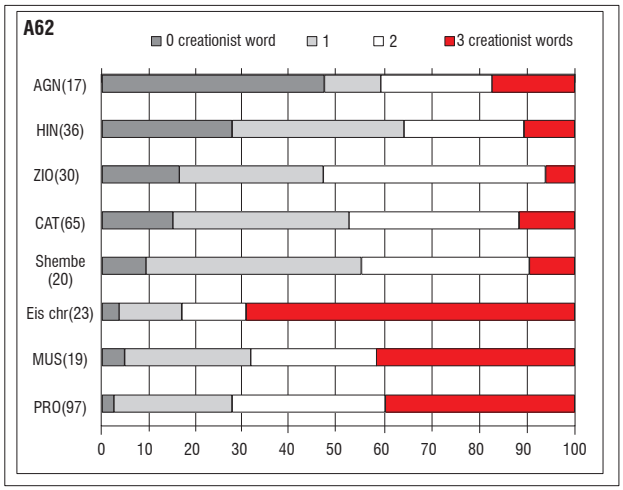

Figure 5: Percentage of teachers (grouped by religious affiliation) who selected 0, 1, 2 or 3 creationist words in Question A62 on the origin of humankind.

As shown in Figure 5, Question A62 highlighted the differences among the groups of teachers. Among Protestant, Muslim and Other Christian teachers, 40% or more selected three creationist terms associated with the origin of humankind. Fewer than 20% of teachers in all other groups chose three creationist terms. At the opposite extreme, more than 40% of atheist or agnostic teachers chose no creationist terms. Over 50% of Hindu, Roman Catholic and Shembe teachers, and about 47% of Zionist adherents, chose either none or one creationist term. Roughly 30% of Protestant and Muslim teachers, and fewer than 20% of Other Christian teachers, chose either none or one creationist term. Unexpected results were that more than 40% of the atheist–agnostic group chose two or three creationist words.

The results for the three questions – as shown in Figure 3 to Figure 5 – illustrate the strong effect that answers to Questions A64, B28 and A62 had on PC1. As mentioned earlier, PC1 was identified by PCA as the strongest component to distinguish between groups of religious affiliation along a continuum of evolutionist to creationist. The three questions consistently and clearly identify atheist and agnostic teachers as holding the most strongly evolutionist views, whereas Muslim, Protestant and Other Christians held the most creationist views. The same questions also placed Hindus, Zionists, and Shembe adherents closer to the evolutionist pole compared with Roman Catholics.

The answers given to the questions also illustrated that about 12% of agnostic and atheist teachers, 20% of Other Christians, 25% of Shembe, Roman Catholic, Protestant and Muslim teachers, and 36% of Hindu and Zionist teachers selected answers that were compatible with a theistic evolution position.

Discussion

Among our sample of South African teachers, a greater number held creationist views than their counterparts in European countries or in South Korea. Fewer South African teachers held creationist views than their counterparts in North Africa or Lebanon. The results obtained in our study differed in several respects from those of other countries sampled in the Biohead–Citizen international study. The main results from 30 countries[60] show important differences among those countries. However, within any country, with few exceptions there were no significant differences among the answers from teachers with different religious affiliations. More Protestant teachers held creationist views than their Roman Catholic colleagues in Brazil, Burkina Faso[60] and South Korea.[37] In Lebanon, slightly more Sunni teachers (but not Shiite or Druze teachers, who are also Muslim) held creationist views than their Christian colleagues.[60] The clear differences linked to religion in our study illustrate a greater diversity of views with regard to evolution than that of other countries.

In South Africa, the views of Protestant teachers appear to be more creationist than their Roman Catholic colleagues'. However, Protestants in South Africa may include adherents of Pentecostal churches in addition to mainstream Protestant churches, which could have skewed our results. Pentecostal churches believe in the inerrancy of the Bible, and one could expect adherents of these denominations to hold stronger creationist views than mainstream Protestants. The group we called 'Other Christian' included respondents who follow mostly Pentecostal and charismatic churches (as classified by Census 2001.[38]) Notwithstanding the difficulties in separating adherents of mainstream Protestant churches from those of Pentecostal or charismatic churches, we noted an almost complete overlap between Protestant, Other Christian and Full Gospel churches. This cluster comprised the broad Christian group with the strongest creationist views of all Christian groups in our study.

The result for Protestant teachers in South Africa is similar to results from some non-European countries, such as Brazil[36,61] and South Korea.[36] It is substantially different from that of European Protestant teachers, who are either Calvinist (as in France), Lutheran (as in Germany) or Anglican (as in UK).

A further finding worth noting is the proportion of teachers (between 20% and 40%) who selected the third option for questions A64 and B28, on the origin of life and humanity respectively. These responses imply a belief system that is simultaneously creationist and evolutionist – the group that Scott[52] refers to as 'theistic evolutionists'. The fact that these teachers constituted a substantial proportion of each religious affiliation in our study supports the view that among teachers with the same religious affiliation, different views are possible across the creationist–evolutionist continuum.

Teachers who hold views that are both creationist and evolutionist should find teaching the subject of evolution less problematic than teachers who hold fundamentalist creationist views. (The latter group was represented by the fourth option for question A64 and B28.) As mentioned earlier, the clearly evolutionist Dobzhansky[53] appeared to have a theistic evolutionist belief system. These results suggest that theistic evolutionists constitute a substantial group among South African teachers.

More importantly, our results illustrate the conceptions of evolution among teachers who follow religions such as Hinduism or African Independent Churches (Zionist and Shembe). Reddy[62] found that a sample of South African Hindu teachers and students experienced no conflict between their religious beliefs and evolution. As shown in Table 1, Hindu beliefs refer to several creation stories, which reduces the possibility of conflict between religious texts and acceptance of 'descent with modification'. The beliefs of Hindu teachers in this study were more evolutionist than those of their Protestant and Roman Catholic colleagues, but less evolutionist than the beliefs of agnostic or atheist teachers. This result can be compared to that observed in South Korea, where the concepts of Buddhist teachers were as evolutionist as those of their agnostic and atheist colleagues.[37] This finding can be explained by the fact that Buddhists, like Hindus, do not have a creation story as one of the central tenets of their religion.

With regard to the African Independent Churches, our results contribute to understanding many teachers' beliefs, because this is the largest church group in South Africa.[37] Although such churches are officially Christian (for instance, ZCC has a strong Pentecostal orientation), the views of adherents of these churches are more evolutionist compared with other Christian teachers'. A possible explanation is the influence of African traditional beliefs and the decreased emphasis on a literal acceptance of the Bible.

Conclusion

This research points to some important findings regarding the conceptions of South African teachers from a broad range of religious affiliations, with regard to evolution. In terms of the influence on their beliefs about evolution, religious affiliation is more important than their subject of specialisation for teaching, or their level of teaching experience. These results contribute to the Biohead–Citizen Project by collecting data for South Africa. In most of the 30 countries already investigated through the Biohead–Citizen questionnaire, there was little difference (within a country) that was related to the teachers' religions. There were a few exceptions, such as the relatively higher level of creationist views of Protestant teachers in Brazil, Burkina Faso and South Korea than their Non-Protestant colleagues. The results presented here show a great diversity in South Africa, possibly linked to a more heterogeneous socio-cultural context than in other countries. Understanding the relationship between teachers' religious affiliation and their positions on the creationist–evolutionist continuum is important if we wish to reduce the conflict teachers may experience when teaching evolution. Interventions could be designed to include pre-service teacher education programmes, and professional development programmes for in-service biology teachers.

Authors' contributions

P.C. was the project leader who initiated the project in South Africa. He was instrumental in the design of the questionnaire that was used in all countries. He contributed to statistical analysis of the data and wrote sections of the manuscript, including the results section. M.S. and A.J. identified possible participants, collected the data, wrote the introduction, background and literature review, and parts of the methods and discussion sections. E.D. adapted some of the questions for the South African context, and refined the results and discussion section.

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