International Journal of Learning, Teaching and Educational Research
Vol. 22, No. 5, pp. 302-318, May 2023
https://doi.org/10.26803/ijlter.22.5.15
Received Feb 10, 2023; Revised Apr 26, 2023; Accepted May 22, 2023

Life Sciences Teachers' Pedagogical Content Knowledge When Addressing Socioscientific Issues in The Topic Evolution

Mokgadi Elizabeth Relela
University of Johannesburg, Johannesburg, South Africa

Lydia Mavuru*
University of Johannesburg, Johannesburg, South Africa

Abstract. The South African life sciences curriculum envisages a teacher who negotiates through controversial issues in the topic of evolution and helps learners reconcile the content and their religious or cultural aspects. Previous studies have found that teachers are conflicted to teach evolution concepts due to socioscientific issues (SSIs) emanating from sociocultural and religious beliefs and those of their learners. Consequently, the current paper reports a study that sought to establish life sciences teachers' topic specific pedagogical content knowledge when teaching some concepts in the topic evolution. This is against the backdrop that teachers are conflicted about teaching the theory of evolution. In a qualitative study, an open-ended questionnaire designed to assess science teachers' Pedagogical Content Knowledge for Biological socioscientific issues (PCK-BSSIs) was administered to selected 28 life sciences teachers who had taught the topic evolution for some time. The findings showed that the teaching of SSIs in evolution through debates, argumentation, and discussions, provides a platform for learner critical thinking, problem-solving and the ability to make informed decisions. Some teachers failed to realise the need for inclusion of evolution in the curriculum considering its invasive and challenging nature with regards to sociocultural and religious beliefs. Teachers therefore used textbook knowledge without engaging learners. Based on these findings, the researchers recommend that teachers be equipped with not only the pedagogical skills to address controversial issues but should also be developed in the subject matter knowledge.

Keywords: Evolution; life sciences; teachers' pedagogical content knowledge; socioscientific issues

* Corresponding author: Lydia Mavuru; lydiam@uj.ac.za

1. Introduction

The theory of evolution is one of the most authenticated theories in the history of science, backed by evidence from many scientific disciplines which include geology, genetics, palaeontology, and developmental biology (Inan et al., 2017). Its contribution and significance in understanding life on Earth have been emphasised repeatedly by important international scientific communities, such as the National Research Council (NRC) (2012). South Africa is home to diverse groups of people in terms of origin, race, and religion, hence its liberal system that allows the practice of religion of one's choice. As such, many Christians, Jews, and Muslims reject evolution because the view opposes their religious beliefs (Barnes et al., 2020; Yahya, 2006). Evolution is, thus, a controversial topic to teach in the life sciences (biology) classroom where there are learners from diverse religious and cultural backgrounds. Concerns have been raised in the scientific community that many teachers, and the public, do not accept the theory of evolution as a scientifically testable phenomenon, and this is evident in the way evolution is taught (Clément, James, & Dempster, 2016).

The South African Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education [DBE], 2011) for life sciences envisages a teacher who is knowledgeable about evolution by natural selection, the evolution of humankind, and biological evidence for the theory of evolution. Ideally, CAPS contemplates a teacher who can negotiate through controversial issues in the classroom efficiently and aids learners in reconciling any religious or cultural aspects that learners might have. Because evolution accounts for 44% of paper 2 in grade 12 life sciences final examination, it implies that teachers should help learners engage with this topic meaningfully. The life sciences teacher becomes a significant determinant in the successful teaching of the theory of evolution in school science (Glaze, 2018). This is against a background that in South Africa, the teaching of the theory of evolution continues to lack a proper direction within many life sciences classrooms (Stears, Clément, James, & Dempster, 2016).

It is however questionable whether the teachers are knowledgeable about the socioscientific issues (SSIs) in the topic evolution and whether they are prepared to teach the topic meaningfully to a diverse group of learners. Previously researchers documented that an antagonism exists between religious and cultural views and the theory of evolution which tends to conflict teachers from willingly engaging with the concepts on the theory of evolution in the life sciences/biology classrooms (Pretorius & Lioy, 2021; Tolman et al., 2020). The argument is that when teaching the theory of evolution teachers lack the pedagogical content knowledge (PCK) to engage the learners fully with the concepts as they are compelled to a certain extent to invalidate their sociocultural and religious backgrounds and those of their learners (Deniz & Borgerding, 2018). Consequently, the current study aims to establish life sciences teachers' PCK when teaching some concepts in the topic evolution. The objectives of the study are: (1). To explore teachers' knowledge of the curriculum for SSIs in the theory of evolution teaching; and (2). To establish teachers' pedagogical content knowledge for teaching SSIs in the theory of evolution. This is against the backdrop that

teachers are conflicted about teaching the theory of evolution due to the many SSIs, which Ruse (2005) labelled as being surrounded by emotionally charged debates and discussions. The study presupposes that by integrating and addressing SSIs when teaching evolution, learners will engage with concepts of evolution meaningfully. In that way, there would be no reason for teachers to exclude certain concepts due to religious or cultural beliefs. This is because learners would have an opportunity to share and deliberate on their belief systems and appreciate the differences in their cultural and religious beliefs and practices in relation to the theory of evolution.

Teachers' abilities to teach are evidenced by the level of their PCK which is the knowledge base that enables teachers to present and transform the content of the subject to make it comprehensible to learners (Shulman, 1986). Teachers' topic specific pedagogical content knowledge (TSPCK) is required, which is a theoretical construct that refers to teachers' capabilities in transforming the comprehension of a given topic into formats that are suitable for teaching (Malcolm, Mavhunga & Rollnick, 2019). TSPCK makes teachers aware of learners' difficulties and assists them to select pedagogical representations and teaching strategies that enhance the learners' understanding of the topic. The upcoming sections discuss the controversy associated with the teaching of evolution.

2. Literature review

2.1. Role of socioscientific issues in scientific literacy

One of the goals of science education is for learners to attain knowledge applicable when dealing with science-related issues that confront them in the complex society they live (Roberts & Bybee, 2014). As such, a well-informed understanding of the consequences of scientific development on society is an obligatory requirement that learners must develop to make informed decisions and enhance the quality of their lives (Sadler & Zeidler, 2009). Though scientific literacy is a complex, multidimensional construct that lies at the heart of contemporary reforms in science education (Cakiroglu & Geban, 2016; NRC, 2012), learners must be taught and enlightened on how to resolve issues and topics that involve science (Sadler & Zeidler, 2009).

Sadler (2009) argued for the incorporation of SSIs in science teaching and learning as it has the potential to promote moral reasoning and learners' personal engagement with conflicting perspectives on issues relevant to their lives and the society in which they live. SSIs may be viewed as "controversial and ill-structured problems that require scientific evidence-based reasoning to inform decisions about such topics" (Zeidler, 2014, p. 10), which arises from the interplay between science and society (Hastürk & Ökkeşoğullar, 2021). An important reality to note is that learners bring their own experiences and perspectives to the learning situation, which creates a potential bridge between school science and the learners' worlds (Bossér et al., 2015; Mavuru & Ramnarain, 2017).

Various strategies have been put forward as suitable when teaching SSIs. These include the use of debate (Simonneaux, 2007); and argumentation which Sadler and Zeidler (2009) regarded as empowering and motivating learners to establish

well-grounded arguments whilst applying scientific evidence to foreground their positions, beliefs, and opinions, regarding the topic. Argumentation can incorporate collaborative learning approaches, where learners are given opportunities to interact with each other as they explain and discuss their claims (Kirchner, Paas & Kirshner, 2009). Previous studies have shown how science teachers were challenged to teach SSIs (Han-Tosunoglu & Irez, 2017; Simonneaux, 2007). In particular, science teachers are reluctant to utilise SSIs in their teaching due to their poor classroom management abilities (Glaze, 2018; Tidemand & Nielsen, 2017); time constraints due to slow curriculum coverage (Tidemand & Nielsen, 2017); and parental reaction, administrative pressures, and feelings of incompetence in content areas (Glaze, 2018). Because of the above reasons, Sadler (2011) lamented the teacher-centredness that characterise many science classrooms that deny learners the autonomy to share ideas through debate and problem-solving. In concurrence, Glade (2018) pointed out that teaching is supposed to have shifted to become learner centred. To ensure meaningful learning of controversial topics in the science classrooms, teachers should possess expertise and understanding of teaching and learning of SSIs (Altınışık, 2022; Han-Tosunoglu & Irez, 2017). Previous research has shown teachers' lack of the content knowledge about evolution and their ill preparedness to teach the concepts meaningly to diverse groups of learners.

Nature of life sciences (biology) teachers

Teachers are the implementers of the curriculum and hence their choices influence what is taught and how it is taught (Aivelo & Uitto, 2019). Previous studies (e.g. (Cheung & Wong, 2010) have shown that teachers' beliefs determine the value they give to the knowledge to be taught and consequently the emphasis made when teaching it. Because of teachers' personal knowledge, which is fluid, a change in the curriculum may not translate into the change of teaching approaches employed (Tidemand & Nielsen, 2017). According to the authors change may only result once the teachers' beliefs about the content and the suitability of the current teaching methods have changed. Thus said, the current paper argues for a concerted effort in involving teachers in curriculum innovations, convince them of the benefits of the change, and provide them with adequate and suitable development.

2.2. Controversy in the teaching of the theory of evolution

There is a growing body of literature that documents how religious and cultural views are antagonistic to teachers' and learners' willingness to engage meaningfully in the teaching and learning of the theory of evolution (Trani, 2004; Smith, 2010; Glaze, Goldston, & Dantzler, 2015; Borgerding, Deniz, & Anderson, 2017). In the life sciences classrooms, teachers are expected to be knowledgeable and prepared to teach the theory of evolution to learners from diverse religious and cultural backgrounds. In fact, the South African CAPS for life sciences stipulates that teachers should explore the "different cultural and religious explanations for the origin and development of life on Earth" (DBE, 2011, p. 65). The expectation is for life sciences teachers and their learners to actively participate in the teaching and learning of the topic despite their religious and cultural worldviews (Pobiner, Watson, Beardsley, & Bertka, 2019). In this regard, Reiss (2019) noted that in the classrooms, teachers tend to select and teach aspects

of the theory of evolution that do not antagonise their religious and cultural belief systems and those of the learners. Such a classroom practice ill-prepares learners for examinations and at the same time defeats the whole purpose of teaching the topic which foregrounds learners' understanding of all the other topics.

In a study to investigate Muslim teachers' conceptions of evolution in several countries, Clement (2015) found that Lebanese teachers from the Christian and Muslim religions tended to be more knowledgeable and better equipped to deal with the theory of evolution in class compared to teachers of Muslim faith from other countries. The unfortunate part is that Clement (2015) found that the Muslim groups who acknowledged the theory of evolution, had reimagined it to exclude the evolution of humankind. Asghar (2013) investigated some Muslim Canadian and Pakistan teachers' views about evolution and found similar results where teachers were willing to accept the evolution of living organisms other than the evolution of humankind. The teachers viewed the theory of evolution of humankind as demeaning their Islamic belief system (Asghar, 2013), which was also echoed by biology teachers and professors from a Middle Eastern society where BouJaoude et al. (2010) investigated their positions regarding biological evolution and evolution of humankind. From these studies it shows how humans safeguard their religious beliefs and do not take kindly to anything that threatens the existence of their religion. This goes to show that spiritual matters (whether Islamic, Christianity, African tradition, etc.) are enduring and can defy logic.

In the South African context, previous researchers (e.g. Ngxola & Sanders, 2008; Coleman, Stears & Dempster, 2015) found that teachers questioned the authenticity of the theory of evolution and that their views influenced the way they taught concepts on evolution. The teachers have also shown a lack of confidence in teaching content for which they felt inadequately prepared (Ngxola & Sanders, 2008; Mavuru, 2018). An important issue to note is that there is a lot of inconsistency in how evolution is addressed in different curricula (Hermann, 2013). For instance, the South African CAPS stipulates that evolution by natural selection and specifically human evolution should be taught, yet it is silent on how teachers should manage religious and cultural belief systems arising from this. Some of the South African life sciences teachers indicated that the theory of evolution is the most complex and controversial topic compared to any other life sciences topics they were teaching (Mavuru, 2018). Therefore, SSIs should be considered as important aspects to foster learners' development in scientific literacy. A recent study to determine how life sciences teachers conceptualise SSIs embedded in the topic evolution found that teachers were aware of the SSIs in the topic which arose from both their socio-cultural and religious backgrounds and those of the learners. The findings showed however that "teachers were conflicted when teaching this topic as they view the teaching of evolution as a way of negating the legitimacy of their religious and cultural beliefs" (Relela & Mavuru, 2021, p. 2). As already alluded to generally people do not take kindly to criticism regarding their belief systems.

2.3. Topic specific pedagogical content knowledge as the conceptual framework

The study is underpinned by PCK as the conceptual framework that helps teachers to transform the content (theory of evolution) and pedagogy to make concepts more comprehensible to learners (Tuithof et al. 2021; Mavhunga & Rollnick, 2016). Because PCK is content-specific pedagogical knowledge (Şahingöz & Cobern, 2020) that takes into consideration the contextual factors teachers find themselves teaching in (Kind, 2009), topic specific pedagogical content knowledge (TSPCK) (Mavhunga & Rollnick, 2013) will be used as the lens to establish how teachers transform concepts on the topic theory of evolution in their classrooms.

3. Methodology

The study is located within an interpretive paradigm which allowed for an in-depth comprehension of the phenomenon in its unique context (Creswell, 2014). In this case, the researchers could obtain valuable insights about the life sciences teachers' PCK when addressing SSIs in evolution. The study adopted a qualitative case study research design (Creswell, 2014) which enabled the capturing and description of teachers' PCK.

3.1. Selection of participants

Using a purposeful sampling technique (Etikan, Musa, & Alkassim, 2016) 28 grade 12 life sciences teachers were selected from six township schools and six suburban schools within the Johannesburg West District of Gauteng Province. The participants consisted of 17 females and 11 males. These included 14 teachers from township schools, eight from suburban schools, and six from Christian independent schools. The sample was suitable because of the diversity of both teachers and learners in terms of sociocultural backgrounds and beliefs which would influence the teaching and learning of the controversial SSIs in evolution.

3.2. Data collection

An open-ended questionnaire designed to assess science teachers' pedagogical content knowledge for biological SSIs (PCK-BSSIs) was administered to the participants. The original instrument was developed by Han-Tosunoglu and Lederman (2016) for use in the USA. The items in the instrument were developed based on Shulman's PCK model (Shulman, 1986; 1987) and results of previous research on SSIs instruction.

The questionnaire was adapted by modifying the topics and scenarios in the questions to focus on the theory of evolution, particularly on evolution by natural selection and the evolution of humankind. Two scenarios were used one on peppered moths to depict evolution by natural selection and the other on phylogenetic tree to depict evolution of humankind. Each scenario was followed by 14 open ended questions related to the scenario. The questions sought to assess teachers' knowledge of the following domains when teaching: (1). knowledge of the curriculum for SSIs in the theory of evolution teaching; (2). pedagogical knowledge for SSIs in the theory of evolution teaching; (3). subject matter knowledge in the theory of evolution teaching; and (4). knowledge of the learners in the theory of evolution teaching. The scenarios and questions were designed to

stimulate the participants to contemplate their conceptions and practices of the theory of evolution teaching and learning.

3.3. Data analysis

Teachers' responses to the questionnaire were assessed using a rubric developed by Han-Tosunoglu and Lederman (2016). The rubric helps to accommodate the responses to each question in one of three different categories: inadequate understanding, eclectic understanding, and reform-based understanding, which indicate the degree to which participants are familiar with each of the given statements or not. Reform-based understanding indicates an in-depth understanding, or deep knowledge, of the teaching of the theory of evolution. Eclectic understanding indicates that the participants showed some degree of understanding about the teaching of the theory of evolution. Inadequate understanding indicates that the participants are not knowledgeable enough, which signifies a lack of knowledge regarding the teaching of the theory of evolution. For the presentation of data, the reform-based understanding and the eclectic understanding were combined to give the proportions of teachers' PCK when addressing SSIs embedded in the theory of evolution.

3.4. Measures ensuring trustworthiness

The selection of the two scenarios for the questionnaire was done by the two researchers after careful analysis of the scope of the curriculum stipulations for the grade 12 life sciences topic on the theory of evolution. The questionnaire was piloted to a group of 10 life sciences teachers who had taught the topic for many years but were not part of the selected participants for the study. After analysis of the teachers' responses, three of the most experienced teachers (10 years+) were interviewed to check for the suitability of the items in relation to the teaching of the concepts on theory of evolution. The feedback was used to change the phrasing of three of the questions which were not clear in terms of the language used. After the actual data collection process, the two researchers coded data from the same five questionnaires independently and compared the analysis. The process was repeated until an intercoder rate of 80% was achieved.

3.5. Ethical issues

Ethical considerations were adhered to as stipulated by the Research Ethics Committee of the institution the researchers worked in.

4. Findings

The findings are presented under the different teacher knowledge domains to show how the PCK of grade 12 teachers manifested when teaching and addressing SSIs embedded in the topic of evolution. To allow a meaningful understanding of the findings, Table 1 presents the context of the participants in terms of their profiles which have a bearing on their understanding of SSIs in the theory of evolution and how they teach the topic.

Table 1. Teachers' profiles

Characteristic	Category	n	Percentage
Gender	Female	17	60.7
	Male	11	39.3
Race	Black	15	53.6
	Coloured	2	7.1
	Indian/Asian	4	14.3
	White	7	25.0
Age (Years)	36-40	10	35.7
	41-45	14	50.0
	46-50+	4	14.3
Religion	Christianity	16	57.1
	Muslim	7	25.0
	Hindu	3	10.7
	African tradition	2	7.1
Type of school	Township (Public)	13	46.4
	Township (Independent)	2	7.1
	Suburban (Former group C)	9	32.1
	Suburban (Independent Christian)	4	14.3
Teaching qualification	Diploma	1	3.6
	Bachelor's Degree	17	60.7
	Postgraduate Certificate in Education (PGCE)	10	35.7
Experience teaching Life Sciences (Years)	0-5	7	25.0
	6-10	12	42.9
	11-15+	9	32.1

4.1. Teachers' knowledge of the curriculum for SSIs in the theory of evolution teaching

Teachers showed that they had various conceptions and interpretations about the curriculum requirements regarding the theory of evolution. There were teachers who interpreted the content in a positive light for instance those who realised the value of the content in affording learners with opportunities to know the various biology fields and careers. Table 2 shows the teachers' positive conceptions.

Table 2. Teachers' positive conceptualisations

Teachers' knowledge about SSIs	Teachers' conceptions (direct quotes)
Knowledgeable about the SSIs embedded in the theory of evolution	Challenges peoples' religious and cultural convictions.
	The formation of new species from existing species
	All living organisms share a common ancestor
	Africa's Eve
	It is the best explanation on how all organisms came to being
	Learners should know their origin
	Learners should know about the science processes
	Learners should know about the theory of evolution so that they can pursue studies related to the topic
	Being a theory, its supported by scientific evidence
	The evolution of humankind versus creation

Teachers viewed the theory of evolution as a topic that encourages learners to solve problems and make decisions by using critical thinking skills. Teachers also pointed out that the theory of evolution by natural selection promotes the learners' ability to critically evaluate and debate issues related to science and society. Some teachers put forward the view that the topic provides learners with argumentative and debating skills. Of particular importance is that several teachers underlined the fact that the theory of evolution by natural selection exposes learners to a new scope of biological studies to stimulate interest in, and create awareness of possible different fields of study.

Others showed their knowledge of the historical events which took place way before the introduction of the topic into the curriculum in 2008. One of the teachers mentioned that South Africa took pride of its place in the World, in 1999 when it was proclaimed "The Cradle (birthplace) of Humankind World Heritage Site", along with the Out of Africa Hypothesis. Teachers in this category put forward the view that when the learners are taught this history, they will be interested in life sciences and possibly become famous palaeontologists who will make discoveries of their own in relation to the evolution of humankind.

The teachers who belonged to the Christian and Muslim religions were honest in admitting that initially, owing to their beliefs about the origin of humankind, they were not convinced of the need for the inclusion of the theory of evolution when it was introduced into the life sciences curriculum in 2008. However, because of the knowledge they acquired during the teaching and learning of the theory of evolution and when they considered some of the evidence noticeable in their everyday life, they could not help but acknowledge the importance of the topic. The teachers in this category demonstrated a strong will to learn more about the theory of evolution.
There were however teachers who showed a lack of an understanding of the curriculum requirements with regards to particularly the evolution of humankind. Table 3 shows some of the teachers' conceptions.

Table 3. Teachers' negative conceptualisations

Teachers' views	Reasons (direct quotes)
Against the inclusion of evolution in the curriculum	They should have excluded the human evolution
	It is just another scientific theory; it is not valid
	Evolution is against the word of God
	Conflicts with human creation, God created humans in his own image
	These questions the religious beliefs of the teenagers who are still vulnerable.
	The content is too long and confusing to learners

An important trait deduced from teachers in this category was their inability to reconcile their religious and cultural convictions with their scientific beliefs. Teachers felt that the theory of evolution is antagonistic to most peoples' religious and cultural convictions, including their own, their learners and that of the community. This begs the question, how will the teachers in this category reconcile their religious and cultural belief systems with their scientific beliefs,

which is the vehicle that allows them to engage learners in discussions and address the theory of evolution? The following is a response from one of the participating teachers in this category,

> *Evolution is against the word of God, the curriculum developers should have considered other peoples' beliefs before deciding to include this topic. Evolution is unchristian. Evolution discredits the Bible.*

4.2. Teachers' pedagogical knowledge for teaching SSIs in the theory of evolution

Table 4 shows the teachers' knowledge and their reasons for the importance of addressing SSIs during the teaching and learning process.

Table 4. Teachers' knowledge and reasons for addressing SSIs

Evidence of teachers' knowledge	Reasons
Importance of addressing SSIs	Improving learners' reasoning and argumentative skills
	Learners become critical thinkers
	For informed decision making
Some SSIs should be addressed, and others should not	Some topics are too sensitive to deal with
	Not suitable to teach young learners
Not important to address SSIs	Do not want to be biased
	Not trained how to deal with controversial topics
	Fear of not being able to control the class

Whilst some teachers showed that they had the pedagogical knowledge to address SSIs in the theory of evolution, others had limited knowledge. For instance, more than half of the teachers viewed inclusion of the SSIs in life sciences teaching as important in promoting scientific literacy in science classrooms. This group of teachers identified teaching strategies such as argumentation as essential in allowing learners to express their belief systems and cultural background which could interfere with their understanding of the concepts taught. They indicated that they engaged their learners in intellectual and meaningful discussions thereby enabling learners to make informed decisions, which is the goal of scientific literacy. Others indicated that they did not see the reason for addressing such controversial issues in the classrooms citing that learners were immature to be engaged in such issues that are very sensitive.

Some of the teachers were upfront in explaining why they did not see the importance of addressing SSIs in the theory of evolution when teaching. These teachers clearly indicated their incapacity to teach them and were concerned that they may end up advancing their thought processes in the classrooms instead of allowing learners to learn the important concepts and issues. Hence, they thought exploring the controversy surrounding the theory of evolution in life sciences classrooms was not a good idea and they would not do it but just teach the concepts as they are using textbooks.

Some of the teachers who had Postgraduate Certificate in Education (three Muslims and five Christians) and three who had BEd (two Christians and one Muslim) as teaching qualifications, indicated that though they were conflicted to

teach evolution before, they did not allow the conflicting ideas and beliefs to be an impediment to learn more and teach about this unifying theory. This shows that the teachers' role and rationale as life-long learners, played an influential role in upgrading their knowledge despite their religious and cultural convictions. One teacher who had the longest life sciences teaching experience pointed that,

> *At the end the day what matters is that learners should be taught science processes and theories and, as such, as a teacher I am bound to operate according to scientific beliefs and not my beliefs.*

In contrast, other participants indicated that the evolution of humankind was generally inappropriate, hence should not be included as part of the evolution content in the grade 12 life sciences curriculum. Some of the responses from these teachers included:

> *Of course, evolution is good for learners to learn about, but they should exclude human evolution, it is wrong; God created humans in his own image, so if we are descendants of apes, what kind of image is He? (Participant 1) and Humans are descendants of Adam and Eve, that's what learners should know, not all these other things which cause confusion (participant 2).*

These teachers' responses show strong religious convictions that teaching the evolution of humankind is derogatory to the Creator, that is, God. In every single exemplification the above responses exhibit an inability to reconcile the evolution of humankind with biblical accounts. As such, the teachers indicated that they will only teach the content as it is in the textbook (teacher centred) without involving learners in discussions or research.

4.3. Teachers' subject matter knowledge for teaching SSIs in human evolution

The questionnaire items were aimed at assessing the life sciences teachers' command of subject matter to teach the theory of evolution of humankind adequately, to ensure conceptual understanding by the learners. Additionally, the items aimed at enhancing teachers' self-awareness of their knowledge about the evolution of humankind, thereby encouraging them to identify their strengths, weaknesses, and difficulties so they could seek content development.

Most of the teachers explained the life sciences concepts in the scenarios and could deduce important aspects that they needed to focus on and emphasise when teaching. More nuanced content knowledge was evident in how the teachers explained the concept of natural selection which involved the paper moths. There were however some teachers who showed that they were not confident to teach the concepts of the evolution of humankind. They did not possess adequate knowledge to engage the learners meaningfully as they failed to give examples of SSIs embedded in the topic that could conflict with their religious convictions and those of their learners. They could not give examples that relate to abortion and stem cell research, that are controversial. These teachers were also ill-equipped to address the SSIs given as examples in the questionnaire.

There were teachers who indicated that they were never taught concepts on the theory of evolution in high school and at university. These teachers comprised of

one who had a Diploma in Education and the four who were in the age category: 46-50+, who had not been taught this content before. This explains their limited subject matter knowledge on this topic. An example of the lack of subject matter knowledge and misconceptions are evidenced by the excerpt from one of the teachers, "*I feel it is important to teach how other creatures have evolved over time, but I don't believe we came from apes. I believe God created us.*" The response strongly suggests that not only do teachers have a problem with the theory of evolution, versus the creation of humankind, but they also harbour some misconceptions on the theory of evolution. The part "*… I don't believe we came from apes…*" is a misconception held by most lay people (i.e., the public in general), but it is concerning if teachers, who are at the forefront of teaching, hold this kind of misconception.

4.4. Teachers' knowledge of the learners when teaching the theory of evolution

Table 2 shows the teachers' knowledge about their learners when teaching the topic. They indicated the need to teach learners about the origin of humankind so that they could appreciate themselves. The following is an excerpt from one of the teachers which justifies the teaching of evolution of humankind to the learners.

> *Yes, the time has come to acknowledge the importance of knowing our origin. When I was still a learner, I don't recall in our biology class learning about where we originated from, we learned everything, crabs, locust, millipede, hydra, you name them, useless things, but we never learned about human evolution, which concerned me directly.*

Table 5 that follows shows teachers' knowledge about their learners, which is an important teacher knowledge domain.

Table 5. Teachers' knowledge about the learners when teaching evolution

Level of knowledge	Evidence
Reformed	Learners should be familiar with science processes
	Learners will become well informed citizens who are able to reason and argue about the matter at hand
	Exposes learners to different fields of work
	Increases learners' interests in life sciences
	Provides background for life sciences subject as a whole
	Learners will be knowledgeable about extinct species
	Learners are given opportunities to recognise and appreciate different perspectives from their peers.
Eclectic	Inability to create a debatable classroom atmosphere
	Debates consume contact time
	Parents will not allow their children to think of evolution instead of creation
	Challenges the religious and cultural beliefs of most learners

Table 5 shows teachers' reformed views about what their learners should learn and what they are capable of. Teachers' knowledge about learners helps in the selection of content to be taught, the identification of teaching strategies, the selection of examples to use and as well as designing learning activities for meaningful engagement with the content. Failure by teachers to consider their learners in the teaching and learning process may result in the teachers denying

learners an opportunity to engage in some of the content and activities pertinent and commensurate with their level. This is evidenced by teachers who displayed eclectic views because they were ill-equipped to utilise teaching strategies such as debates which are suitable for addressing SSIs and providing learners with opportunities to explore multiple perspectives. In such a situation learners' development of scientific literacy is compromised. Whilst there are teachers' responses categorised as reformed, it could be possible that not all of the teachers had that understanding in reality. Some participants may just respond in the positive yet in practice it is the opposite.

5. Discussion

The study sought to establish life sciences teachers' TPCK when teaching some concepts in the topic evolution. Teachers' TSPCK (Mavhunga & Rollnick, 2013) has been used as the lens to establish and interpret how teachers transform concepts on the theory of evolution in their classrooms. There were teachers who understood the importance of teaching evolution to learners, hence embracing the curriculum stipulations. There were however some who viewed the inclusion of evolution particularly evolution of humankind as invasive to their religious beliefs and those of their learners. These views were also found by previous researchers (Asghar, 2013; Clément, James, & Dempster, 2016; Reiss, 2019) where teachers lacked confidence in the theory. There were teachers who showed a lack of understanding of the need to teach the topic evolution and showed limited TSPCK, which Malcolm, Mavhunga and Rollnick (2019) describe as teachers' capabilities in transforming the comprehension of a given topic into formats that are suitable for teaching and comprehension by learners.

There were teachers who indicated that they were never taught concepts on the theory of evolution in high school and at university. The situation was also exacerbated by the curriculum document which is silent about the way teachers should teach the controversial concepts whilst addressing the SSIs. This is despite the CAPS document envisioning a teacher who can negotiate through controversial issues in the classroom efficiently whilst aiding learners to reconcile any religious or cultural aspects they may have with the concepts to be learned (DBE, 2011). As such, Hermann (2013) alluded to a lot of inconsistencies in how evolution is addressed in different curricula. Based on the findings in this study, it shows that there was a mixed bag in terms of life sciences teachers' pedagogical content knowledge when addressing socioscientific issues in the topic evolution.

6. Conclusions, Limitation, and Recommendation

This study explored how grade 12 teachers' topic specific pedagogical content knowledge manifest when teaching and addressing socioscientific issues on the topic of evolution. Key issues that arose from the study are that: (1). The curriculum does not give details of how teachers can teach the theory of evolution whilst addressing SSIs; (2). There are variations in teachers' knowledge and skills regarding SSIs in the topic and how they can be taught meaningfully; (3). The use of debates, argumentations and discussions engage learners meaningfully when addressing SSIs in evolution; (4). Teachers' belief systems and those of the learners

impede effective teaching of the topic; and (5). Some teachers had limited content knowledge since they had not studied evolution in high school and university.

The findings of the study provide important aspects which require serious consideration by curriculum policy developers, teacher professional development service providers, and the teachers themselves. Such consideration includes targeted teacher professional development in terms both content and pedagogy. In the context of South Africa in-service science teacher development, should be prioritised in terms of both content and pedagogy each time curriculum changes are made. It is only through in-service teacher professional development that all teachers old and new may be equipped with appropriate knowledge and skills. The limitations of the study include the consideration of teachers' self-reports only as the only data collection method without considering observing teachers' practices through lesson observations. Future studies may investigate teachers' PCK when addressing SSIs based on students' perspectives and when presenting actual lessons.

Acknowledgements
This paper culminates from the work done by the first author Mokgadi Relela for her MEd study at the University of Johannesburg. We also acknowledge the unwavering participation by the in-service teachers without whose responses the study could not have materialised.

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