In–service Teachers' Knowledge and Misconceptions of Global Warming and Ozone Layer Depletion: A Case Study

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Abstract

The South African curriculum assessment and policy statement (CAPS) envisions a learner who embodies numerous principles which include commitment towards a healthy environment. This behoves in–service teachers to expose learners to environmental education (EE) throughout the education system. To be able to do this, they need to have tangible levels of environmental literacy (EL) on various issues of environmental concern. This paper reports on a case study conducted in the North West province of South Africa to explore the EL of in–service teachers regarding global warming and the depletion of the ozone layer. Fifteen teachers participated in this interview–driven qualitative research inquiry. The findings suggest that some in–service teachers hold various scientific misconceptions regarding global warming and the ozone layer. These findings corroborate those of previous studies involving pre–service and in–service teachers. The researcher recommends support to help enhance the EL of in–service teachers, in respect of topical issues such as global warming and the ozone layer. Additionally, due the dearth of research that focuses on the EL of in–service teachers on issues explored in this study, globally, the researcher also posits that more research similar to this one is essential.

Keywords:
environmental education, environmental literacy, evaluation criteria, global warming, in–service teachers, ozone layer

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Introduction

Many countries, globally, acknowledge the role of environmental education (EE) in addressing existing, emerging and potential environmental challenges that threaten the survival of future generations. The fundamental goal of EE is to contribute towards the development of an environmentally literate citizenry that possesses knowledge, skills, attitudes and values to enable them to take pro–environment actions (Sagala, Nuangchalerm, Saregar & El Islami, 2019; Goldman, Yavetz & Pe'er, 2014). It is for this reason that, over the past few years, many countries have revised their school curricula to accommodate EE (Summers, Kruger, Childs & Mant, 2000). The Republic of South Africa is one of those countries.

Since the dawn of democracy in 1994, which culminated in the introduction of a new public school curriculum, the South African public school curriculum has been revised a number of times with each revision accommodating, or at least expressly emphasising, the importance and the need for the inclusion of EE in pedagogy. For example, the White the South African *White Paper on Education and Training* of 1995, the blue of the post–apartheid curriculum, makes reference to the importance of environmental learning in the curriculum (Department of Basic Education, 1995). Likewise, Curriculum 2005 also known as C2005, which came into being in 1997, also recognised the importance of environmental education. The Revised National Curriculum Statement(RNCS), which replaced C2005 in 2002, "tried to ensure that all Learning Area Statements reflect the principles and practices of social justice, respect for the environment and human rights as defined in the Constitution" (DBE 2002, p.10). The National Curriculum Statement Grades R – 12 (NCS), popularly known as the Curriculum and Assessment Policy Statement (CAPS), which was implemented from the beginning of 2012; highlights among its principles the commitment of government to "*human rights, inclusivity, environmental and social justice: infusing the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa*….issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors" (DBE 2011, p. 5). For this reason, the CAPS advocates for the integration of environmental issues in all subjects and grades, commencing in Grade R (known as Kindergarten or the Preschool Class elsewhere) to Grade 12.

In light of the preceding points, logic dictates that, as a consequence of curriculum transformation; for the South African public school teachers to fulfil the mandate of implementing EE, they need to have the requisite knowledge of environmental issues. Without a doubt, at a far deeper level, they also need to exude much more than just a 'parochial' understanding of environmental challenges; teachers must also demonstrably epitomise commitment towards inculcating the spirit of values, attitudes and beliefs that direct the learners towards pro–environment actions. After all, as Kaur (2013, p. 12) argues, for a meaningful implementation of EE to occur; "teachers require knowledge and skills on

environmental awareness". In essence, for teachers to be able to implement environmental education, they need to have sound knowledge of various issues of environmental concern. In recent times, due to the profound impact that these issues have on the environment, topical environmental issues such as the depletion of the ozone layer and global warming have arguably received more attention than many other issues of environmental concern; hence it is not unreasonable to expect in–service teachers to be knowledgeable about these issues. Additionally, meaningful knowledge and awareness among teachers in respect of topical issues such as global warming and ozone depletion may enable them to empower learners on sustainability ideals of "green growth, green economy and new climate economy" (Kasayanond, Umam & Jermsittiparsert 2019, p. 466). These ideals are, arguably, essential in advancing environmental sustainability for the survival of future generations. It is thus the view of this researcher that studies that seek to investigate the knowledge of in–service teachers in respect of ozone depletion and global warming, as this one seeks to do, are necessary.

It is evident from literature that a lot of work has been done, which focuses on the EL of pre–service teachers, with specific attention to the concepts of global warming and ozone depletion (e.g. Yalcin & Yalcin, 2017; Dal, Alper, Özdem–Yilmaz, Öztürk & Sönmez, 2015; Çokadar, 2013; Çakir, Irez & Doğan, 2010; Kaya, 2009; Papadimitriou, 2004; Dove, 1996). However, numerous researchers have noted that, globally, little has been done in respect of in–service teachers in this area (Herman, Feldman & Vernaza–Hernandez, 2017; Liu, Roehrig, Bhattacharya & Varma, 2015; Michail, Stamou & Stamou, 2006).

Previous Work

Notwithstanding the fact that, as mentioned above, there is a paucity of research that focuses on the environmental literacy of in–service teachers, for the purposes of contextualising this study, a few points on some of the work that has been done in respect of global warming and the depletion of the ozone layer are necessary. Liu et al. (2015) conducted a study, which involved 19 secondary school science teachers, with the view to investigate, among other things, the attitudes and knowledge of in–service teachers on global climate change as well as how these, possibly, related to their pedagogical practices. These researchers found, inter alia, that the majority of the respondents considered global climate change to be, mainly, human–induced. Furthermore, they noted that most of the teachers in that study had serious scientific misconceptions regarding the causal–relationship between global warming and the 'holes' in the ozone layer. According to them, global warming causes the 'holes' in the ozone layer.

In another study, Michail, Stamou & Stamou (2006) investigated the environmental literacy of 155 primary school teachers with focus on the respondents' conceptions of acid rain, the depletion of the ozone layer and the greenhouse effect. Theses researchers found that, in the main, the participants had

knowledge gaps and held misconceptions about the three phenomena. For example, although 45% of the respondents knew that the continuous destruction of the ozone layer enables more harmful insolation to reach the earth and, thereby, cause harm to life on earth; 52% erroneously attributed the depletion of the ozone layer to global warming. Also, these researchers found that only 20% of the teachers knew that ozone is found on the upper atmosphere as well as the lower atmosphere.

In the same vein, Daskolia, Flogaitis & Papageorgiou (2006) conducted a study involving 159 Kindergarten teachers. This study was kick–started with a directive that each teacher should "write down the first 5 words that came to mind when hearing or reading the term "ozone layer"" (Daskolia et al. 2006, p. 171). In this study, the researchers found that the majority of the respondents were aware of the important role played by the ozone layer in terms of *buffering* ultra–violet (UV) sunrays from the earth. Likewise, these respondents also knew that the destruction of the ozone layer leads to harmful UV sunrays reaching the earth, culminating in harm to various forms of life on earth. However, just like some of the respondents in the studies mentioned above, these teachers had a misplaced view that global warming destroys the ozone layer.

Herman, Feldman & Vernaza–Hernandez (2015) conducted a study which involved secondary school science teachers. They enlisted 102 and 118 teachers who taught in Florida (FL) and Puerto Rico (PR), respectively. They found that almost all PR and over 70% of FL teachers believed that the depletion of the ozone layer, the use of pesticides and the use of aerosol cans contributed to climate change. Furthermore, 90 % of PR teachers compared to 40% of FL teachers, erroneously, believed that nuclear energy causes climate change. And, that 81% of FL and 85% of PR teachers, correctly, believed that emissions from industries and the destruction of forests are primary contributors to climate change.

Problem of the Study

Invariably, an inception of any new curriculum is accompanied by much fanfare interspersed with a tinge of uncertainty and a myriad of high, albeit unrealistic, expectations. Marsh (2009, p. 102) refers to these expectations about the new curriculum as 'dubious assumptions' because society, especially those in positions of authority, tend to erroneously expect that in–service teachers "will be able to, **innately and promptly**, teach it at a high level of technical proficiency" (Marsh, p. 102) **[emphasis by this researcher].** The question that this study attempts to answer is: what level(s) of environmental literacy do South African public school teachers have to enable them to integrate global warming and the ozone layer in pedagogy?

The literature reviewed in preparation of this paper suggests that the above–mentioned question has not been asked since the dawn of democracy in 1994. Therefore, it is the contention of this researcher that in a country such as South Africa, which has undergone numerous modifications of the school curriculum, with

some inclination toward EE integration in pedagogy; by now, researchers should have made numerous attempts towards responding to this question.

Therefore, this suggests that, even though some might argue that the CAPS curriculum is almost ten years into implementation and thus this study bears no relevance; this researcher is of the view that there is a serious need to explore the environmental literacy of in–service teachers, especially, in South Africa. This is essential since there is, virtually, no research that comes from this country that focuses on topical issues such as global warming and the depletion of the ozone layer.

Method

Research Model

This study uses an interpretive qualitative research approach. The researcher was mindful of the fact that because the respondents would be unique individuals and that, each of them would perceive the world differently from other people. For that reason, the interpretive approach was deemed an appropriate strategy as it enables the researchers to make sense of the meanings assigned by each respondent to the phenomena under investigation (Daymon and Holloway 2011).

Participants

This study was conducted in Maquassi Hills Education sub–district. This area forms part of a bigger district known as Dr Kenneth Kaunda, which is one of four major districts of the North West Provincial Department of Education (NWDE) in the Republic of South Africa (RSA). The NWDE is one of the nine provincial departments of education of the RSA. A total of 15 in–service teachers were, purposively and opportunistically (Etikan, Musa and Alkassim 2016), selected from a total of approximately 278 teachers distributed across 4 secondary schools and 7 primary schools in the rural towns of Makwassie and Wolmaransstad to participate, voluntarily, in this inquiry. Of the 15 respondents, 4 females and 4 males were stationed at two different primary school while 4 females and 3 males were in two different secondary schools.

Each of the teachers was professionally qualified to teach at the South African public schools. Additionally, with the exception of two teachers, all the teachers taught the subjects in which they majored during their training. The following subjects were 'represented' in this study; history, life sciences, geography, agricultural science, mathematics, home economics, physical science and languages. The teaching experience ranged from 2 years (1 respondent) to over 30 years (2 respondents). The following table sums up the characteristics of the respondents:

Table 1.

Respondents' Profiles

Variables	Numbers	Variables	Numbers
Gender		*Age*	
Female	8	21 – 30yrs	1
Male	7	31 – 40yrs	10
		41 – 50yrs	2
School type		51+	2
Primary	8		
Secondary	7	*Teaching Qualifications*	
		Teacher's diploma	8
		Bachelor's degree	3
Teaching Experience		Bachelor's degree and Teacher's diploma	4
≤ 5 yrs.	1		
5 – 10	10		
15 – 20 yrs.	2		
≥ 21 yrs.	2		

Data Collection Tools

In order to obtain in–depth perspectives of participants (Babbie, 2001; Garber, 1996) on environmental issues under investigation, data generation was done through the use of one–on–one interviews. Prior to conducting the interviews, with the view to probe each respondent's conceptualisation of global warming and the ozone layer, an interview protocol was developed to guide the semi–structured interviews. This interview protocol was handed over to two experts for their input and, thereafter, it was piloted on a sub–sample (Kanjee, 2006) of three teachers from one school within the demarcated area. Furthermore, it needs to be mentioned that the work by Dove (1996) and Summers, Kruger and Childs (2001) on global warming and the ozone layer was found helpful in enabling the researchers decide on what constitutes an '*appropriate*' or '*acceptable*' definition/explanations of these concepts.

Although the interviews were conducted in English, each respondent was given the latitude to use the language of their choice (Bryman and Bell, 2007; Le Grange, 2000). Consequently, the respondents used the following languages; English, Afrikaans, Setswana and Sesotho – all of which are official languages of the RSA. Each respondent consented to the audio–recording of interviews. The audio–records eased the transcription which occurred once data collection was completed.

Data Analysis

Construct conceptualisation was used to analyse and interpret data. This approach enabled the researcher to determine and reflect on the way in which the respondents "think, understand or make sense of experiences, phenomena or particular relationships" (Robertson 1993, p. 98). Construct conceptualisation as used in this investigation was informed by Corbin and Strauss's (1990, p. 7) view that, "concepts are the basic unit of analysis…statements made by subjects may be condensed into categories and classified according to a particular mode of classification/category decided upon by the researcher…categories must be developed and related". The process of construct conceptualisation enabled the categorisation of each response or set of condensed responses provided by the respondents into four evaluation criteria which had been decided upon by the researcher. The four criteria (i.e. *no environmental literacy*, *nominal environmental literacy*, *functional environmental literacy* and operational *environmental literacy*) used for evaluating the environmental literacy of each respondent with regard to each of the two environmental issues covered in the inquiry were adapted from Loubser, Swanepoel & Chacko (2001). These criteria can be summed up as follows:

- *No environmental literacy* – the respondent appears to have no knowledge of the concept(s)/issue(s) discussed.
- *Nominal environmental literacy* – the response(s) suggest that the respondent is able to recognise a particular concept/phenomenon and can provide the basic meaning of the concept/issue.
- *Functional environmental literacy* – the respondent manifests a broad knowledge of the concept/environmental issue and can distinguish a particular concept/environmental issue from, or relate it to, other environmental concepts/factors.
  Furthermore, the individual is able to mention the function(s) and/or effect(s) of a particular phenomenon to the environment or to other factors components of the environment.
- *Operational environmental literacy*– the respondent shows progress beyond functional literacy both in terms of depth of understanding and skills, i.e. is able not only to reflect on environmental issues/concepts but can also demonstrate an ability to suggest solutions to challenges facing the environment, and/or is also able to present and/or defend an argument in respect of personal beliefs, attitudes or values in relation to an environmental issue.

Trustworthiness

Trustworthiness of the findings was ensured through, inter alia, member checking, which was aimed at 'accurately' capturing the perspectives of the respondents as intended by them. This was done with the view to enhance the credibility of the findings (Shenton, 2004). On the other hand, dependability was enhanced by

ensuring that data interpretation is supported by evidence and that frank and detailed account of the research process is provided (Van der Riet and Durrheim, 2006; Lewis and Ritchie, 2003).

Ethical considerations

Each respondent was fully informed, through one–on–one interaction with the researcher, about the purpose and the need for this study before they could participate. Furthermore, anonymity and confidentiality were assured and applied throughout the study. This was, in part, done, through the use of the letters of the alphabet to conceal the identities of the respondents. The respondents were also informed that they were free to withdraw from the research anytime if they so wished.

<div align="center">Findings</div>

Respondents' Views on Global Warming

During the one–on–one interview process, each respondent was asked to: define the concept of global warming, mention some causes of this phenomenon, comment on its effects on various components of the environment and, provide recommendations on how they believed global warming could be addressed. The findings can best be summed up in the following table.

Table 2.
In-service Teachers' Views on Global warming

Respondent	Definition	Causes	Effects	Solutions	EL Levels
A	No	No	No	No	NOEL
B	No	No	No	No	NOEL
C	No	No	No	No	NOEL
D	No	No	No	No	NOEL
E	Yes	No	Yes	No	FUEL
F	No	No	No	No	NOEL
G	Yes	No	No	No	NEL
H	No	No	No	No	NOEL
I	Yes	Yes	Yes	Yes	OPEL
J	Yes	Yes	Yes	Yes	OPEL
K	Yes	Yes	Yes	Yes	OPEL
L	Yes	Yes	Yes	Yes	OPEL
M	Yes	Yes	Yes	Yes	OPEL
N	Yes	Yes	Yes	Yes	OPEL
P	Yes	Yes	Yes	Yes	OPEL

Key To Table 2: "**No**" suggests that the respondent had no knowledge/understanding of the concept/environmental issue while, "**Yes**," suggests some knowledge/understanding of the concept/environmental issue. The acronym "**NOEL**" stands for *No Environmental Literacy*, "**NEL**" stands for *Nominal Environmental Literacy*, "**FUEL**" stands for *Functional Environmental Literacy*, and, "**OPEL**" stands for *Operational Environmental Literacy*.

Comments on the Preceding Table

The negative "No" in **table 2**, under the definition column, suggests that six respondents *(***A, B, C, D, F** and **H** could not to define the concept of global warming, four of them admitted that they had no idea about the concept while the other two gave responses which suggested that they lacked understanding of the concept. The following interaction with **Respondent B** points to this lack of understanding/knowledge of the concept.

Researcher: What do you think is the meaning of the concept global warming?

Respondent B: According to my understanding, I think when you are talking about global warming you are talking about floods.

Researcher: What about floods?

Respondent B: Sometimes when it rains…when it rains heavily…. you would find that there is strong wind in the whole process, and then it ended up being the floods…because…the strong air makes the building to rattle. So, sometimes you find that…the strong wind makes the house roofs fall down. So I think that is what we call floods.

Researcher: So, in essence, would you say the concept of floods is synonymous with global warming?

Respondent B: I think so.

On the other hand, as indicated by the negative "Yes" in table 2 under the same column, nine respondents (**E, G, I, J, K, L, M, N** and **P**) had an idea, partial or complete, of global warming. These respondents had an idea that global warming has to do with the rise in global temperatures. For example, **Respondent G** believed that global warming is "when the earth becomes too hot" while **Respondent I** said that "global warming is climatic change that occurs due to the emissions of greenhouse gases".

In respect of the causes of global warming, eight respondents (**A, B, C, D, E, F, G** and **H**) had no idea what causes global warming while seven respondents (**I, J, K, L, M, N** and **P**), were able to mention some factors, which they believed to be the causes of global warming. For example, **Respondents K, L, M** and **P** suggested that global warming is caused by *the contamination of the atmosphere* caused by *smoke from homes, vehicles and factories* (**Respondents I, J, K, M** and **N**), *the emission of greenhouse gases* (**Respondents L** and **P**) which, in turn, lead to "more heat being trapped" (**Respondent L**). According to **Respondent I**, "factories contribute to global warming by emitting too much carbon dioxide and other deadly gases". Additionally, "poor waste management" (**Respondent N**) was also cited as the possible cause of global warming.

Regarding the effects of global warming, seven respondents (**A, B, C, D, F, G** and **H**), demonstrated a lack of idea while eight respondents (**E, I, J, K, L, M, N** and **P**) had some idea regarding the effects of global warming. For example, respondents (**L, M** and **P**) referred to possible deaths of animals and plant species and, "animals losing their natural habitats" (**Respondent J**). **Respondents, L** and

P cited the *melting of ice in arctic parts of the world* which results in *the rise in sea level* (**Respondent P**). **Respondent I** believed that global warming is responsible for "serious economic loses that lead to poverty because it affects the productivity of the land". According to this respondent, global warming leads to drought, which in turn, contributes to "economic loses".

In respect of dealing with global warming, eight respondents (**A** to **H**) had no idea how global warming needs to be 'handled' while seven of the respondents (**I** to **P**) seemed to have some ideas. These respondents suggested, inter alia, that "factories should stop disposing greenhouse gases like methane" (**Respondent P**) and "limit the emission of greenhouse gases by avoiding deforestation" (**Respondent L**). **Respondent M** suggested that "legislation be passed on the emission of greenhouse gases" (**Respondent M**). **Respondent I** suggested that people should "think green… and, that …. Sustainable development must become fundamental in education".

Respondents' Views on the Ozone Layer

With regard to the ozone layer, each respondent was asked to: provide a definition of the concept of ozone layer, state the function(s) of the ozone layer and, suggest ways in which the ozone layer could be protected from harm, i.e., if they believed that it was under harm.

Table 3.

In-service Teachers' Views on the Ozone Layer

Respondent	Definition	Function	Measures to deal with the destruction of the ozone	EL Level
A	No	No	No	NOEL
B	No	No	No	NOEL
C	No	No	No	NOEL
D	No	No	No	NOEL
E	No	No	No	NOEL
F	No	No	No	NOEL
G	Yes	No	No	NEL
H	No	No	No	NOEL
I	Yes	Yes	No	FUEL
J	Yes	Yes	No	FUEL
K	Yes	Yes	No	FUEL
L	Yes	Yes	Yes	OPEL
M	Yes	Yes	No	FUEL
N	No	No	No	NOEL
P	No	No	No	NOEL

Key To Table 3: The concepts **"No"**, **"Yes"**, **"NOEL"**, **"FUEL"** and **"OPEL"** have the same meanings as in **TABLE 2**.

Comments on the Preceding Table

As indicated by the negative "No" in **table 3**, under the definition column, nine respondents (**A, B, C, D, E, F, H, N** and **P**) could not to define the concept of ozone layer; five of them by admission and the other four through their responses. For example, **Respondents B** and **F** referred to the ozone as *one of the layers of the atmosphere* while **Respondent N** claimed that the ozone layer is "a layer of polluted air in the atmosphere that disturbs sunlight". **Respondent P** believed that it is the "layer in the atmosphere that stops gases going into space and separating the sun's rays so that they don't reflect directly on the earth".

On the other hand, as indicated by the "Yes" in **table 3**, six respondents (**G, I, J, K, L** and **M**) provided responses that suggested that they did have some idea regarding the definition of the concept of ozone layer. For example, according to **Respondents K** and **L**, the ozone layer *is a layer of oxygen in the atmosphere*, this *oxygen is compressed* and "consists of three oxygen atoms in its molecules" (**Respondent I**).

Regarding the function(s) of the ozone layer, ten respondents (**A, B, C, D, E, F, G, H, N** and **P**) admitted to not knowing anything concerning the role of the ozone layer. On the other hand, five respondents (**I, J, K, L** and **M**) provided responses that demonstrated some understanding of the function(s) of the ozone layer. For example, according to **Respondents I** and **L** "it protects the earth against ultra–violet rays". **Respondents J, K** and **M** said that "it minimises the amount of ultra–violet rays that reach the earth".

Concerning the protection of the ozone layer from harm, twelve respondents (**A, B, C, D, E, F, G, H, J, M, N** and **P**), admitted that they had no ideas on how the ozone layer could be protected. However, three respondents (**I, K** and **L**) provided some responses in respect of possible measures to deal with the destruction of the ozone layer. For example, **Respondents I** and **K** believed that it may be possible to prevent the destruction of the ozone layer by "minimising pollution". For them, this meant *reducing smoke from the factories* because *smoke sometimes contains harmful substances that harm the ozone layer*. However, neither of the two respondents could mention the *harmful substances that harm the ozone*. On the other hand, respondent **L** suggested that the "general use of CFCs should be stopped … it harms the ozone layer".

Discussion

The findings of this study suggest that, effectively, between six and eight respondents had no idea regarding global warming. For example, according to the criteria developed with the view to evaluate the environmental literacy of the respondents in this study, six respondents had *no environmental literacy* regarding the environmental issue known as global warming as they could not even define the concept 'global warming'. Likewise, eight respondents had no idea what causes global warming while seven respondents could not state the effects of this phenomenon. The lack of environmental literacy regarding global warming was also discernible in respect of suggestions on how global warming could be addressed.

Eight respondents could not proffer any suggestions on how this phenomenon could be 'handled'. As indicated later in this discussion, these findings corroborate many findings made by previous studies which involved both pre– and in–service teachers.

Compared to the findings on global warming, an even greater number of respondents demonstrated a lack of understanding of the concept of ozone layer. This is discernible from the fact that ten respondents could not state the function of the ozone layer while twelve respondents could not mention even one possible way in which the ozone layer could be protected. These findings, too, confirm the findings made by other researchers, that teachers, both pre– and in–service, have misconceptions or complete lack of understanding of topical environmental issues such as the depletion of the ozone layer (Gungordu, Yalcin–Celik and Kilic, 2017; Khalid, 2001).

Notwithstanding the above–mentioned points, it is worth noting that, in terms of numerous views pertaining to both global warming and the ozone layer, certain parallels could be drawn between a few of the respondents in this study and those in a few other studies. For example, Çokadar (2013, p. 259), points out that previous studies involving pre–service teachers "revealed that trainee teachers held conceptions about the ozone layer, global warming and acid rain different from scientific knowledge". Likewise, there are certain views that were presented by the respondents in this study, which suggest that these respondents held unscientific views about global warming and ozone layer. For example, in this study, some respondents seemed to hold an erroneous and non–scientific view that smoke from homes and vehicles causes global warming.

Likewise, in a study involving in–service teachers, conducted in the UK, Summers *et al.* (2000, p. 304 – 305) point out that in discussing global warming, some of their respondents used statements such as, "rise in mean global temperature," "the fear that the polar (ice) caps are going to melt…sea–levels are going to increase" and so on. Similar responses were also used in this study in reference to global warming. Likewise, in a study involving pre–service primary school teachers conducted in the UK, Boyes, Chambers and Stanisstreet (1995, p. 136 – 137) about the ozone layer, found that most of the respondents "affirmed it was high in the atmosphere… affirming the idea that it was gaseous… almost all of the students knew that the ozone layer protects the earth from solar UV radiation…. almost all of the students associated chlorofluorocarbons (CFCs) with ozone layer damage".

In this study too, some respondents (e.g. **Respondents J, L & P**) referred to the melting of ice in certain parts of the world being the result of global warming. Likewise, Respondent P also referred to global warming as being responsible for the rise in sea–level. With regard to similarities related to the ozone layer, at least two respondents (**I & L**) knew that the ozone layer shields the earth from UV–rays and, one respondent (**L**), also knew that CFCs cause damage to the ozone layer.

In rounding off this section, it is essential to mention that it should be evident from the findings that the majority of the respondents, eight in respect of global warming and twelve in respect of ozone depletion, demonstrated a lack of understanding and awareness of these topical issues. Accordingly, this researcher deemed it irrelevant and non–essential to present variable distinctions among the respondents. Indeed, it would serve no purpose to argue, for example, that teachers of specific subjects or participants of a specific gender/sex demonstrated a better or lesser understanding, as the case maybe, of global warming and/or ozone depletion. Also, given the fact that this study focused on a small geographical area and covered a small sample, the study is not necessarily intended to enable generalizations of the findings but rather it best serves to highlight the need for more research in this under researched terrain.

Conclusion and Implications

In this case study, the researcher explored the environmental literacy of in–service teachers employed in the South African public school education system. This was necessary as it would shed some light regarding the extent to which in–service teachers are equipped to integrate environmental education in classroom activities, as per the requirements of the CAPS curriculum in South Africa (DBE, 2011). Additionally, in light of the dearth of research that focuses on the environmental literacy of in–service teachers, it was necessary to undertake this inquiry. It is the view of this researcher that this study does, albeit to a limited extent, contribute towards ameliorating the paucity of research in respect of the environmental literacy of in–service teachers. Indeed, the findings of this study suggest that there is a need of studies with focus similar to the one of this inquiry.

The findings of this study, corroborate the findings of previous studies that focused on global warming and the depletion of the ozone layer, in respect of both pre– and in–service teaches. Just like a number of previous studies, some of the naïve views and misconceptions, regarding global warming and the ozone layer, noted by various researchers regarding both pre– and in–service teachers (e.g. Yalcin & Yalcin 2017; Liu, Roehrig, Bhattacharya & Varma 2015; Michail, Stamou & Stamou 2006; Papadimitriou 2004; Summers, Kruger & Childs 2001; Dove 1996) were also noted in the participants of this study. For example, some respondents seemed to think that global warming is caused by smoke from homes, factories and vehicles and, that the ozone layer is just one of the layers in the atmosphere. In fact, one respondents even went further to say that the ozone layer is a layer of polluted air in the atmosphere. The respondents suggested, therefore, that by minimising the emission of smoke, the ozone layer could be saved. Clearly, these views are devoid of any scientific truth and should, thus, be cause for concern.

Additionally, it needs to be mentioned that, as Uys and Gwele (2005, p. 105) assert, more often than not, an introduction of the new curriculum presents with it

the need to empower the teachers with knowledge and skills to enable them to, meaningfully, implement the new curriculum. Based on the findings of this study, the argument by Uys and Gwele (2005) cannot be more relevant. Indeed, it is not simply enough to idealise, as the South African public school curriculum seems to do, that environmental education should be integrated in pedagogy. There is a need to ensure that in–service teachers are empowered to meet the needs and demands of the curriculum. Accordingly, if topical issues of environmental concern such as global warming, the depletion of the ozone layer and many other environmental issues are to be effectively addressed in pedagogy, then it should not be assumed that in–service teachers are knowledgeable, skilled and have the commitment towards accommodating such issues in pedagogy. Therefore, the departments of education (both in South Africa and elsewhere) should not just introduce new curricula but they also need to think of in–service teacher programs that seek to provide support to teachers so that they are able to fulfil the mandates of these curricula; especially, the mandate of ensuring the implementation of environmental education. These programs could be presented in collaboration with institutions of higher learning.

In rounding off, based on the findings of this study, it is the view of this researcher that more studies that seek to investigate the environmental literacy of in–service teachers are needed, globally. In the context of South Africa, such studies would contribute towards enabling relevant authorities determine whether the integration of EE, as per the mandate of the curriculum, is realizable. In the global context, such studies should help expand the literature base which, as this study argues, is deficient. This would help scholars in identifying areas that require more attention in respect of enhancing the environmental literacy of in–service teachers.

Limitations of the Study

The major limitation of this study is that a limited number of in–service teachers participated in this inquiry and that it focused on a very small geographical area. Accordingly, any generalization of the findings should be done with caution. Be that is it may, it is the view of this researcher that despite any conceivable constraints, the aim of this study was achieved. Likewise, the researcher considers this as a preliminary study that needs to be followed by larger inquiries.

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