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Pre-Service Teachers and Climate Change: A Stalemate?

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Abstract: Findings from the second phase of a study of pre-service teachers' attitudes to environmental education and knowledge of climate change are reported in this paper. A sample of 87 pre-service teachers participated in a survey study in the last year of their Bachelor of Education degree to examine developments to their attitudes to environmental education and their knowledge of climate change as a result of training. Results showed their attitudes towards environmental education were consistently favourable, but their climate change science knowledge had not changed as a result of their participation in their degree. Data on preservice teachers' sources of knowledge for climate change, their views on important substantive climate change knowledge for their future students and their perceptions of gaps in their own training in relation to climate change were also investigated in order to triangulate the survey data. Implications for preservice teacher education are discussed.

Introduction and Background

This study is concerned with climate change education for those training to teach the next generation of school students. The next generation of students need to be prepared to address highly complex sustainability challenges such as climate change, food scarcity, a burgeoning global population, and loss of biodiversity. Climate change alone threatens to undo and even reverse the progress made towards meeting the Millennium Development Goals and poses one of the most serious challenges to achieving sustainable development for the international community (Anderson, 2012). Mitigation and adaptation are two ways to address climate change (IPCC, 2012). 'Mitigation' focuses on interventions to reduce greenhouse gas (GHG) concentrations through measures that cut GHG emissions or remove carbon from the atmosphere, which can range from investment in clean energies to forest conservation and reforestation. Due, however, to already high GHG concentrations in the atmosphere, some effects of climate change are predicted to continue despite mitigation. Therefore, adaptation, which involves reducing the vulnerability of natural and human ecosystems to the impacts of climate change through modifications in social, ecological and economic systems, is imperative.

One of the necessary prerequisites for mitigation action is an acknowledgement that climate change is a problem caused by human activities (Reser & Swim, 2011). While the majority of scientists agree that it is very likely (a 90 % chance) that anthropogenic carbon emissions are the main cause of climate change (Somerville, 2010), Australians appear to be less than unanimous in their acceptance of the causes of climate change, and public concern for climate change has been declining (Lewandowsky et al., 2013). One reason proposed for this decline is the creation of doubt by political and media bodies, challenging the existence of scientific consensus (Bacon, 2011; O'Neill, 2013). The education sector therefore offers a

most important conduit to help counter media and political effects upon citizens' ambiguous climate change understanding and knowledge.

Since the causes of climate change are at least partly linked to human activities, these activities need to be first identified so that, for instance, one can change consumption patterns by switching to renewable forms of energy and designing greener technologies. Thus, mitigation requires education to learn how to change lifestyles, economies and social structures that are based on excessive GHG production. Education can show people that as conscious consumers and responsible citizens, they have a critical role to play in redefining their lifestyles to address the current sustainability issues that humanity is facing. The topic of climate change in particular, Dawson (2015) contends, is the most important socio-scientific issue that teachers of all age groups could choose to address, given its political and contentious nature. This is especially important because research has revealed that those who have the least understanding of climate change are most likely to trust sources of information that are untrustworthy and to fail to differentiate between relevant and irrelevant criteria when judging the trustworthiness of sources (Bråten, Strømsø & Salmerón, 2011).

It has been reported that knowledge and understanding of climate change was unacceptably low in preservice teachers (PSTs) in Australia, including those secondary specialists citing science and environmental studies as their focus of study (Boon, 2010; Groves & Pugh, 1999) with similar findings demonstrated in PSTs in Canada (Puk & Stibbards, 2012) and the US (for example, Lambert & Bleicher, 2013). Such problematic gaps in knowledge and understanding are not restricted to PSTs. Studies conducted with diverse US university students report that this population also holds an array of misconceptions about the basic causes and consequences of climate change (Cordero, Todd, & Abellera, 2008; Kerr & Walz, 2007; Khalid, 2003; Viscusi & Zeckhauser, 2006; Wachholz, Artz, & Chene, 2014). For instance, when Cordero et al. (2008) examined meteorology undergraduates' understanding of the connection between personal energy use and climate change, two-thirds (N =123) believed that energy-saving light bulbs had no effect on climate change and the production of electricity was "greenhouse gas free".

In light of education's integral role in effecting behaviour change for mitigation, universities and schools have a key role to play (Pandey & Vedak, 2010), with the caveat that education alone is not sufficient but rather an important prerequisite for mitigation action and adaptation behaviours. For example, while Lorenzoni, Nicholson-Cole and Whitmarsh (2007) looked at barriers to adopting mitigation actions for climate change in an adult UK sample, they found lack of knowledge about the causes, consequences and potential solutions to be an important barrier to mitigation and adaptation actions. But other barriers were also identified, some connected to knowledge gaps, others linked to the nature of climate change or cultural influences:

- Uncertainty and scepticism about the causes of climate change, effectiveness of actions from international to individual levels;
- Mistrust in information sources;
- Externalising responsibility and blame on the causes and solutions, expecting governments and industry to take the lead;
- Climate change perceived to be a distant threat in space and time;
- Reluctance to change lifestyles due to threat of mitigation action on standards of living;
- Social norms and expectations which prevent one from acting if others are not also doing so.

In Australia, the context of this research, the 2013 fourth annual survey of over 5000 Australian adults found that while 81% agreed that climate change is occurring, less than half (47%) ascribed it to anthropogenic causes (Leviston, Price, Malkin, & McCrea, 2014) which suggests that less than half of Australian adults would consider mitigation actions to be important.

Preservice Teachers and Climate Change Education

The focus of this paper is upon pre-service teacher (PST) education for climate change, because effective PST education has the potential to prepare and enable future citizens, namely those attending schools currently, to enact mitigation and adaptation actions. The United Nations Educational, Scientific and Cultural Organization (UNESCO)'s declaration that the years 2005–2014 constitute a decade of sustainability education and their request that 'all levels and forms of existing educational and teaching and learning programmes need to be reviewed and re-orientated to address the causes and consequences of climate change' has resulted in a focus on sustainability and teacher education internationally (UNESCO 2009, para. 1). The transformative role of education has long been recognized by ancient Greek and Chinese scholars, and more latterly it has been advocated by significant education philosophers like John Dewey and Paulo Freire. Education has, until more recent years, typically aimed to develop more equitable and just societies. It is once again called upon to help society to attain a more sustainable future. So teachers are looked upon to help in 'bringing about the changes required to achieve sustainable development' (UNESCO, 2010, para. 2), and therefore teacher education programs must help teachers recognise their responsibility in building a sustainable future (Shephard, 2008). Jickling (2013) stressed that it is an ethical imperative to empower school aged children to participate in future adaptation by giving them tools to be able to grapple critically and creatively with climate change to achieve what the current generation appears incapable of achieving in a timely manner. An important tool for this purpose is knowledge. This is because knowledge has been shown to be one of the predictors of pro-environmental behaviour generally (Heberlein, 2012), in youth (for example, Meinhold & Malkus, 2005), in college students (Levine & Strube, 2012) and school students (for instance, Skamp, Boyes & Stanisstreet, 2013).

Knowledge based on authentic mastery experiences (Bandura, 1997) has a twofold function for PSTs. Apart from helping to guide their personal behaviour it is also one the strongest predictors of PSTs' teaching self-efficacy; their confidence for approaching tasks in the classroom effectively and successfully, including curriculum material development (Poulou, 2007; O'Neil & Stephenson, 2012). Given that research has shown that the two most frequently cited socializers of children's pro-environmental behaviour are the family and teachers (Chawla, 2009; Duarte, Escario, & Sanagustín, 2015) it is vital that teachers are well equipped to provide students with the best sources of information to enable them to make reasoned decisions about the environment and other socioeconomic issues that will confront them. Discernible connections between PSTs' knowledge, their enacted pedagogy in the classroom and their students' subsequent pro-environmental attitudes and behaviours have been empirically demonstrated in secondary school students (Skamp, Boyes & Stanisstreet 2013) in a cross cultural study of Australian and English students. Therefore, when teachers elaborate and discuss particular subjects like climate change through their teaching, whether explicitly or via their expressed attitudes or the hidden curriculum that they adopt, it all becomes part of the perceived pedagogy that students experience so it can play a significant role in the formation of the students' environmental attitudes (Strong, 1998).

Although direct connections between teacher expertise and pro-environmental student behaviour are difficult to measure empirically because of the almost insurmountable difficulties involved in controlling for the range of variables that impact upon classroom learning (for an extensive review see Hattie, 2012) and the drivers of pro-environmental behaviour, which depend on demographic factors, institutional, economic social and cultural factors, as well as intrapersonal factors such as motivation, environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities and priorities (see Kollmuss & Agyeman, 2002 for a thorough examination of these factors), PSTs' knowledge of the basic science of climate change is nonetheless a factor that deserves attention, since it is a necessary, if not sufficient, requirement for developing pedagogically sound learning experiences for school students from the earliest years of school. Further while it is acknowledged that the hitherto ascribed linear relationship between knowledge, awareness, attitude, and pro-environmental behaviour does not sufficiently explain how adult pro-environmental behaviour is facilitated, since adults' responses have been shown to be influenced by their political and religious affiliations and identities (Kahan, Jenkins-Smith & Braman, 2011) the same cannot be said for developing children and adolescents. So when there are professional requirements to demonstrate certain minimum standards of content and pedagogical knowledge before securing a teaching post, it is not unreasonable to expect that tertiary programs will ensure that these minimum requirements are met.

Prior Studies

A literature review was conducted to investigate the issues that have emerged and have been examined in relation to PST education for climate change. Studies on pre-service teachers' ideas about climate change (Dimitriou, 2002, 2003; Dove, 1996; Groves & Pugh, 1999; Groves & Pugh, 2002; Khalid, 2001, 2003; Papadimitriou, 2004; Summers, Kruger, Childs, & Mant, 2000) revealed that pre-service teachers held misconceptions and misunderstandings about climate change. For example, Papadimitriou (2004) stated that PSTs misunderstood the science behind ozone depletion, acid rain and climate change. They confused weather with climate and they incorrectly relate ozone depletion, acid rain and climate change. Moreover, Papadimitriou (2004) revealed that PSTs are unaware of appropriate mitigation actions for climate change. Ikonomidis, Papanastasiou, Melas, and Avgoloupis (2012) also reported serious misconceptions in Greek PSTs about the causes, consequences and possible mitigations and adaptation actions for climate change. As well, Lambert, Lindgren, and Bleicher (2012) showed that PSTs had some misconceptions about the causes and consequences of climate change. Only one study reported adequate climate change knowledge in PSTs (Ambusaidi et al., 2012). All other reviewed studies consistently showed a significant and alarming lack of knowledge. In Australia, Boon (2010) highlighted a general confusion in relation to scientific concepts like the greenhouse effect or the ozone layer in an Australian final year PST sample which included PST specialising as science teachers. It was also demonstrated that PSTs' positive attitudes towards, or self-reported familiarity with, topics like climate change did not correlate with their scientific knowledge (Boon, 2011). These findings suggest PSTs have limited or no exposure to science content relating to climate change at tertiary level, or alternatively insufficient understanding of these topics.

Linked to these considerations are questions about the sources of PSTs climate change knowledge. Little research has been conducted to clarify this. Two studies utilising a survey design reported public media and school education as common knowledge sources (Boon, 2010; Ikonomidis et al., 2012). It is not yet clear however, how various knowledge sources

relate to PSTs' knowledge of climate change science. Further, it is not known, for example, which particular aspects of climate change science or its impacts PSTs want more training with in order to teach them effectively.

The Research Context

In Australia, PST education has been slow in building the capacity of new teachers to teach topics that underpin sustainability challenges such as climate change (Dyment & Hill, 2015; Steele, 2010). Evidence suggests this is because there is limited or no core environmental or sustainability knowledge or pedagogy in pre - and in-service courses and programs available to teachers (Bjorneloo & Nyberg, 2007; Ferreira, Ryan & Tilbury, 2007). These findings are exacerbated by the lack of sufficiently knowledgeable supervising teachers for PSTs on practicum. Cutter-McKenzie and Smith (2003) reported that Queensland primary teachers appear to be operating at a level of ecological illiteracy, a finding supported by Taylor, Kennelly, Jenkins and Callingham, (2006) who voiced concern with the level of understanding of sustainability concepts in the teacher population overall. This is the case despite UNESCO's (2005) call for governments to include Education for Sustainability into all primary and secondary school curricula and the Australian Curriculum Assessment and Reporting Authority's (ACARA) (2013) mandate to make sustainability a cross-curriculum priority which many Australian schools have committed to incorporating in their programs. As a result PSTs' and in-service teachers' lack of confidence and preparedness to teach socio-scientific issues under the sustainability agenda has been identified as one of the key barriers to its implementation (Evans, Whitehouse & Gooch 2012; Kennelly et al., 2012; Nolet, 2009).

The research context of this study nonetheless is a university which is a pioneer in introducing sustainability matters into its educational mission; a university whose Strategic Intent includes a strong commitment to producing graduates with the expertise required for the sustainable development of tropical communities (James Cook University [JCU], 2015). This originated from a Federally-funded Curriculum Refresh project that sought to systemically incorporate a clear sustainability focus in the university's programs (JCU, 2014), and research activities which are focused on meeting the sustainability challenges facing the tropical region. Part of this initiative was the development of a compulsory first-year subject (or unit) in the B.Ed., *Foundations of Sustainability in Education*, designed to address and embed sustainability issues. The subject engages PSTs in the underlying science and complexity of socioecological challenges like global climate change and premature species extinction, through inquiry, place-based learning, experimentation and consideration of classroom pedagogy. Topics related to climate change, energy, water, biodiversity, agriculture and population health are all addressed in the subject which was delivered to PSTs for the first time recently. Included the B.Ed. degree is another subject that also involves issues of sustainability, though it is not exclusively designed to do so. *Service Learning for Sustainable Futures,* a compulsory final year subject which is also compulsory, is designed to provide experiences tailored to the interests of the PSTs. These are broadly speaking aimed to help PSTs see and build connections that strengthen communities with a focus on activities that promote social and environmental responsibility. During the course of their training PSTs specialising to teach children up to Grade/Year 7, also study a subject in their 3rd year that addresses science concepts and pedagogy. In sum, the university as a whole, a multi-campus institution, and within it, the teacher education program are imbued with a focus on sustainability and climate change scholarship.

Study Rationale

This research specifically tracked climate change knowledge of 87 PSTs training to be Primary teachers and Early Childhood Educators, from their entry into their B.Ed. degree to their exit in fourth year. It examined amongst other things whether participation in the subjects offered by the B.Ed. course, including a standalone subject focused on embedding sustainability topics and their underpinning science into the curriculum, had an impact on PSTs' knowledge of climate change science and their attitudes about environmental education. Initial research was conducted with this group of PSTs upon entry to assess their baseline knowledge and value for environmental/ sustainability education with the intent of using the results to inform the first year standalone subject (Boon, 2011). Results from that study (Boon, 2011) showed that upon entering the degree course PSTs endorsed the value of environmental education for sustainability and claimed they intended to include education for sustainability in their future teaching.

At this point it is important to emphasise that education for sustainability, and embedded socio-scientific topics like climate change science and strategies to mitigate it, are equally appropriate to teach in early childhood settings as in later school years. As Davis (2014) stressed, children involved in a range of Australian and overseas case study projects have "learnt scientific knowledge and processes, combined with ways to engage as active and informed citizens 'making a difference' in matters of local importance. It's not too young to start EfS!" (p.5). Davis cites studies which report that children have learnt about where food comes from (Japan), using digital technologies to communicate with community members and parents to clean up local parks (Korea), campaigning against battery hen farming (Sweden), and a range of projects involving water and energy conservation, recycling, understanding food cycles through gardening, learning about and preserving local habitats and wildlife, and so on. Sustainability issues and topics have been addressed in childcare centres, kindergartens, schools and the local community (see Davis & Elliott, 2014; Davis, 2010 for details).

The hypothesis of this study is that PSTs enter the degree program with a range of attitudes about environmental education and climate change and varying levels of engagement and knowledge about the causes and basic science of climate change. It was further hypothesised that initial knowledge, attitudes and engagement would be enhanced as a result of their experiences in the B.Ed. program and the milieu of this particular university, as posited by Bronfenbrenner (1979). Bronfenbrenner recognised that an individual's development in any specific domain, including their attitudes and values, is influenced by and subject to the environmental influences that they experience, whether those are through personal interactions, through activities that they actively engage in friendship groups, family circles, work circles, defined as the microsystems that they participate in, including school attendance and courses they complete, or through influences that originate in more distal contexts which filter to them via proxy means, such as the media or government policies, issues originating in what Bronfenbrenner defined as the exosystem or macrosystem of their country. In relation to the influence of training upon environmental attitudes, prior studies of Australian PSTs' attitudinal change arising from studying specific environmental education subjects have been ambiguous. Some have shown significant improvements in PSTs attitudes toward the environment (Taylor, Kennelly, Jenkins, & Callingham, 2006) while others have not (Kennelly, Taylor & Maxwell, 2008). While specific studies on PSTs' environmental attitudes have not focused on empirically validating Bronfenbrenner's proposition directly, it was recently confirmed through a study with 15 year old students. Duarte, Escario and Sanagustín (2015) examined the environmental attitudes of 172,066 15 year old students from 6432 European schools in 28 countries and looked at the association of a range of

family, peer, cultural and school variables using the 2006 PISA data; they demonstrated that the students' cultural milieu did indeed influence their environmental attitudes. The authors concluded that social context needs to be taken into account when designing specific environmental education strategies. Given that the university where this research took place has a strong and explicit focus on climate change research and sustainability in all its documents, logos and banners, the emphasis of climate change education for sustainability should be consistently heard by all undergraduates, making at least one of the immediate social contexts of the undergraduates one that promotes pro-environmental attitudes.

Aims

The aim of this study was to estimate the efficacy of the B.Ed. program in preparing PSTs to understand climate change science to the level that a secondary school student would be expected to have reached by Grade 10. To do this PSTs' attitudes to environmental education and their knowledge of the basic rudiments of the science of climate change were examined two times, upon entering their B.Ed. degree course and at exit four years later. As noted earlier, the program contains three compulsory subjects covering environmental sustainability and science, science pedagogy and social (and ecological) sustainability, delivered in the 1st, 3rd and 4th years of the program respectively. PSTs perceptions of gaps in their knowledge and their sources of information about climate change were also qualitatively surveyed to triangulate the knowledge PSTs as estimated by the multi choice knowledge questions. Finally their views on what they considered their students should know about climate change were sought in order to gain a fuller understanding of their climate change conceptions and the relative importance they placed on climate change education.

Methods

This study utilized a mixed methods embedded research methodology (Cresswell, 2013). The purpose of the embedded research design was to collect both quantitative and qualitative data simultaneously but to have one form of data play a supportive role to the other form of data. In this case the open ended questions were designed to illuminate PSTs' engagement with climate change by eliciting their views about what knowledge their future students should know, their perceived gaps in knowledge and the sources of their own information, matters not easily captured by the multi-choice knowledge questions. The author constructed the original instrument which included simple demographic questions along with groups of questions exploring the participant's attitude to, and self-efficacy for, environmental education as well as their perceived and actual knowledge of a range of environmental sustainability issues (Boon, 2011). The instrument, which was used to explore the links between PSTs attitudes and their knowledge of environmental issues, was constructed by two academics engaged in environmental and science education and educational psychology to ensure its items had appropriate content validity. It was then piloted on a sample of PSTs to ensure that their response to the items was appropriate for the final survey administration. The instrument was also independently statistically validated and was found to have robust factorial validity (Effeney & Davis, 2013). The multiple-choice knowledge questions were based on subject matter classified under three domains of sustainability education as described by the OECD (2009, p.20) designed to capture the knowledge of 15 year old students. The original instrument included 21 questions, but these were reduced to only 7 pertaining to climate change for this study which was specifically

concerned with climate change knowledge (Appendix A). Responses to open-ended questions on the survey were analysed by the constant comparative method (Glaser & Strauss, 1967). This involved two independent researchers who examined PSTs' responses and constructed a range of categories that reflected a number of emergent themes in response to each of the three questions. It was anticipated that these questions would provide insight into PSTs conceptualisation of climate change education and the sources of these conceptualisations.

Ethics clearance was obtained prior to administering the anonymous survey to PSTs to gauge their initial climate change science knowledge, among other socio-scientific issues and a subsequent survey using a reduced number of identical attitudinal (4) and knowledge questions (7) about climate change was used in their fourth year to ascertain if there were any changes to their baseline knowledge and attitudes. The final survey also asked PSTs to name the sources of their knowledge, identify the gaps in their own knowledge and specify topics they thought their students should know in order to make informed decisions about climate change mitigation and adaptation for the future.

In accordance with ethics conditions, the first year survey was administered by a research assistant during the latter half of an introductory lecture in semester 1, during their first year and during the information session for their final practicum in semester 2, of their final year. The goals of the study and the nature of the research were explained and the students were given the opportunity to ask clarifying questions. An information letter along with the questionnaire was distributed to those who expressed interest in participating. The information letter stated that participation was voluntary. Those who participated dropped the completed questionnaire into to a box at the door of the lecture theatre as they departed where the research assistant was waiting. Survey analyses were performed using the SPSS statistical package (IBM SPSS Inc, 2014).

Results

The sample size, gender, age and specialist areas for both waves of the research are shown in Table 1. Some attrition in numbers occurred between first and final year; the response rates were 89 % (First Year) and 92% (Fourth Year).

		First Year		Fourth Year	
		N = 96	N %	N = 87	N %
AGE	20-25	54	56.2	65	74.7
	26+	14	14.6	22	25.3
	17-19	28	29.2	0	0.0
GENDER	male	10	10.4	10	11.5
	female	86	89.6	77	88.5
SPECIALIST AREA	ECE	31	32.3	31	35.6
	Primary	65	67.7	56	64.4

Table 1 Sample characteristics, First and Fourth Year

Table 2 summarises responses to attitudinal questions at the two points in time. Analyses of Variance (ANOVA) results show that PSTs' confidence about preparing suitable teaching modules for their students (Q1) and (Q2) did not significantly change. Their beliefs about the importance of their role to help solve environmental problems through teaching (Q3) and their belief in the importance of education to solve environmental problems (Q4) also remained stable from first to fourth year.

Survey questions	**First**		**Fourth**		**ANOVA**
					F (*p*)
	Mean	SD	Mean	SD	
Q1. I am confident that I can prepare accurate teaching modules about our environment	3.09	0.55	3.11	0.56	F(1,175)=0.097 $p < 0.75$
Q2. I cannot include education for the environment in my teaching because it should be taught by specially trained teachers	3.35	0.62	3.23	0.62	F(1,181) = 0.71 $p < 0.40$
Q3. I can play an important role in solving environmental problems through teaching	3.23	0.47	3.27	0.65	F(1,173) = 0.19 $p < 0.65$
Q4. It is very important to educate school students about our environment from an early age	3.57	0.54	3.62	0.56	F(1,176) = 0.43 $p < 0.52$

Table 2 Attitudinal question responses across First and Fourth Years

Table 3 summarises rates of correct answers to the knowledge questions across the two waves of the research. It is of interest and concern that correct answers to those questions (Appendix A) assessing the scientific processes underpinning climate change, respiration/ photosynthesis, the water cycle and the structure and function of the atmosphere were significantly lower than the questions that simply required climate change awareness. A correct answer to the question about sources of anthropogenic carbon emissions and the cause of climate change, both higher than at entry, the latter significantly higher ($F(1,163) = 7.8$, $p < 0.005$), could be given on the basis of what PSTs hear around the university campus through informal discussions. In other words, they could be answered correctly without necessarily understanding the scientific process involved in climate change, that is, the greenhouse effect or photosynthesis and respiration. The answers to the question about the water cycle show a significant improvement over their entry baseline responses which might be due to the environmental sustainability subject that they all undertook, although correct responses were still well below half. It is of concern that this group of PSTs appear to have forgotten much of their high school science and the process questions that they would have been exposed to at high school in their science subjects since their answers to the question assessing their understanding of photosynthesis and respiration were significantly lower than they were upon entry to the B.Ed. (51.8% correct down to 30.7% correct, $F(1,143) = 6.6$, $p < 0.01$). This was also the case with their response to the question exploring their understanding of the impact of climate change upon Australian farmland ($F(1,171) = 22.4$, $p < 0.001$). As for the aggregate knowledge mean scores, those attained in the final year (2.9), were not significantly different from that achieved in first year (2.6), ($F(1,182) = 2.819$, $p < 0.95$) and showed that no-one achieved a perfect score of 7. The most common score (the mode) was 3 out of 7 possible correct answers.

Knowledge questions	Correct answers (%) (1st Year)	Correct answers (%) (4th Year)	ANOVA *F* (*p*)
Climate Change is caused by…	72.7	75.0	F(1,174) =0.12, *p*< 0.73
The ozone layer has been mainly depleted by…	50.6	55.7	F(1,175) =0.46, *p*< 0.50
The biggest environmental threat to Australian farmland as a result of climate change is …	65.9	31.8	F(1,171) =22.4 , *p*< 0.001
Some water, a small amount of soil, a few green aquatic plants and a fish were placed in a large bottle. The bottle was sealed to prevent the exchange of gases…. Is carbon dioxide produced by the plants?	51.8	30.7	F(1,143) =6.6 , *p*< 0.01
Greenhouse gases in the lower atmosphere (troposphere) absorb…	28.2	21.6	F(1,164) =0.97, *p*< 0.33
The major source of anthropogenic carbon emissions comes from…	37.7	59.1	F(1,163) =7.8 , *p*< 0.005
The major human impact on the water cycle is….	3.9	19.3	F(1,162) =9.4 , *p*< 0.005

Table 3 Rates of response to knowledge questions by year level.

Total Knowledge Score	Total knowledge	
	1st Year	4th Year
	N %	N %
0.00	8.3	1.1
1.00	12.5	13.6
2.00	26.0	21.6
3.00	28.1	34.1
4.00	17.7	17.0
5.00	4.2	9.1
6.00	3.1	3.4
7.00	0	0

Table 4 Total knowledge score First and Fourth Year

In order to further explore PSTs' views on climate change and on how to improve their training through the degree, three open response questions asked them to state gaps in their knowledge and pedagogy, their sources of information and their views on what they considered important to teach their students to enhance their climate change awareness. The last question was designed to probe their understanding of the climate change science and the importance they placed on it. Results of these questions are tabulated (Table 5).

Questions 6, 7 & 8		ECE (%)	PRI (%)
Q6. What specific topics within subject areas should your students know in order to make informed decisions about mitigation and adaptation for the future?	don't know	7.4	4.8
	main school subjects, (maths, history)	3.7	26.2
	mitigation actions	25.9	14.1
	scientific knowledge	14.8	2.4
	human impact	0.0	4.8
	consequences of climate change	0.0	2.4
	opposing views to climate change	3.7	7.4
	integrate issue across subject areas	3.7	0.0
	multiple answers from the categories: scientific knowledge, solutions, human impact, cultural[1], consequences	40.7	37.9
Q7. List the main sources of your knowledge	don't know	0.0	5.0
	no formal education	0.0	2.4
	school education	6.9	2.4
	tertiary subjects - non education	10.2	12.2
	tertiary education subjects	13.7	9.7
	professional knowledge/ experience (teacher aide experience, colleagues, unit planning for assignments, activities for use in classroom, pedagogical frameworks, curriculum documents)	5.8	12.2
	media[2]	37.6	29.0
	critique of PST training and sustainability subjects	10.2	7.3
	practical activities (research projects, tutorial experiments, investigations, inquiry based learning, field trips, group activities)	13.7	19.5
Q8. List gaps in your content and pedagogy knowledge	don't know	0.0	7.4
	nothing /few gaps	4.5	14.8
	many gaps - unspecified	27.2	14.8
	human impact- human action causing climate change	4.5	11.1
	local issues	9.1	7.4
	scientific knowledge	13.6	3.7
	pedagogy	22.7	7.4
	Sceptics	4.5	14.8
	Suggestions (for delivery of sustainability & climate change content)	9.1	14.8
	government actions +solutions + mitigations	4.5	3.7

[1]Cultural: this category included problems in other countries, solutions from other countries, Indigenous perspectives, personal experiences.
[2]Media: this included a range of electronic media, websites, news, documentaries, movies, internet, google, TED talks;

Table 5 Responses to open questions 6, 7, and 8 (4th Year) by specialist area (N = 87)

Results of Q6 suggest that a quarter of the primary cohort and a tenth of the ECE PSTs may not specifically know which areas their students should be familiar with since they suggest main school subjects such as maths in their answers. However, the focus on mitigation actions and answers with multiple suggestions including solutions, mitigation and the like, suggest that most ECE and PRI PSTs are engaged with and consider the issue of climate change worthy of attention. A small percentage (7.4%) of primary (PRI) and early childhood educators (ECE) (3.7%) PSTs appeared to be climate change deniers.

Results of Q7 indicate the main sources of PSTs' knowledge about climate change are the media and other web based materials which comprised a quarter to a third of PSTs sources of content knowledge. This result raises some questions for PST training. Are PSTs turning to the media because their training is perceived as incomplete or because they believe that the media provides a more balanced perspective on climate change? Perhaps their training stimulated an interest in climate change that led them to access more programs on climate change or web sites about it. About half of all PSTs cited tertiary education in some

form as their source of knowledge; given that their knowledge score on fundamentally basic high-school level science was in general low, and that they all undertook a minimum of three specific subjects designed to teach them about sustainability, climate change and related issues as well as related pedagogies with which to relay science to their students this results needs further urgent investigation. Retroactive interference with their memory might have caused the results here. An attitude that they can look things up as needed might also have served to make PSTs less active learners of the specific topics. This was specifically noted by one of the PRI PSTs: *"I think the course covers it well enough. As mentioned before I would always do my research and know what I was teaching. The JCU course cannot possibly cover all the content knowledge required to teach all year levels everything they need to know!"* About a fifth of all PSTs critiqued the delivery of the content relating to climate change and sustainability and offered suggestions for improvement, such as "*the materials should be more integrated across the degree"* (Primary PST).

Curiously results of Q8, suggest that some PSTs were aware that they had many gaps in their knowledge generally (27.2% (ECE) and 14.8 % (PRI)), in their scientific knowledge specifically (13.6% (ECE) and 3.7% (PRI) and their pedagogy (22.7% (ECE) and 7.4% (PRI)). Once more the climate change sceptics were vocal in their responses, about 20% of the total cohort. Results revealed a number of vociferous climate change deniers (4.5% ECE and 14.8% PRI); their views were represented in the critique category. For example*: "I am still not sure whether I 100 % agree with climate change but that is not because I haven't been educated on it"*. And: "*I don't believe in the importance of sustainability!"* (PRI specialists)

Answers to the open ended questions by those who achieved a high knowledge score (5 or over) (N = 7) and a low score (l or 0) (N=10) were examined separately to identify themes present in the two groups (Table 6). These PSTs like others of the cohort cited personal interest activities and the media as sources of their knowledge with some from both high and low scoring groups citing formal university subjects as well. Many also mentioned practical activities and projects, though these were low scoring students.

PST (score/7)	Open response questions		
	Q 6. What should your students know?	Q 7. Sources of Knowledge	Q 8. Perceived gaps in knowledge
1) (6/7)	Nothing offered	Own interest in sustainable practice, fuels.	Nothing offered
2) (5/7)	Natural climate changes and effects. Ways of sustainability to minimize effects - preferably positive, long-term solutions. Intergenerational equity. Future thinking.	Undertaking the sustainability subject and science pedagogy subject - outline modules, face to face lectures, assignments, reading, internet websites, and books professional experience and personal interest, media news, documentaries, information from curriculum documents.	Teaching about carbon emissions and government programs. Teaching about positive ways to minimize climate change.
3) (5/7)	Littering - recycling (science) walking more/riding or use of public transport.	Research activities, environmental days, use of ICT, TV.	Nothing offered
4) (5/7)	Science	Have knowledge - personal learning - also many university subjects, ICT's, lectures, investigations, small group activities	Basic knowledge on impacts
5) (5/7)	Science: Protecting reef/rainforest - local environments. sustainability - global footprints (deceasing carbon footprint)	Internet, experience, university. The uni subject where we had to actually implement a sustainability unit. Though we were also given the opportunity to just volunteer at an organisation and pretty much was a waste of time.	Nothing offered
6) (5/7)	Studies of Society and Environment (SOSE) - electricity, water conservation; Science; Maths.	Personal interest, I enjoyed online video's on the topic	Nothing offered
7) (5/7)	SOSE - how they can prevent climate change, conservation & sustainability. Maths - data on climate change. Science - Effects on living things. English. HPE. Technology - How technology contributes to climate change. History - comparisons between then and now in relation to the environment.	One of the main sources of my knowledge was my 4th Year sustainability class that I undertook. The biggest learning activity was the service learning project where I designed a whole school program for Carnarvon Gorge National Park. Also my teacher's aide experiences.	My mind is coming up blank at the moment!
8) (1/7)	What environmentalists believe and also those who have completely opposite view. Both perspectives. Drama - politics of so called climate change. English, no idea	I can't remember much about the subject. I rely on the Internet, TV etc. for knowledge.	Everything

9) (1/7)	Renewable energy, sustainability, litter and waste, water pollution	Documentaries, uni, research, activities, face to face.	I think the course covers it well enough. As mentioned before I would always do my research and know what I was teaching. The JCU course cannot possibly cover all the content knowledge required to teach all year levels everything they need to know!
10) (1/7)	Life cycles, habitats, needs of living things	Nothing offered	Global warming, climate change
11) (1/7)	Sustainable living, natural environmental changes - soil erosion, human impacts on environment.	Formal science/ SOSE education	Applying sustainable knowledge to class
12) (1/7)	Sustainability - environmentally friendly practices, i.e. reduce, reuse, recycle. Biodiversity - we have an individual and collective responsibility to protect and improve the biodiversity of our local environment. SOSE and science.	SOSE - Eco challenge (Cattana Wetlands) - hands on, inquiry based learning.	Nothing offered
13) (1/7)	Greenhouse gases, clearing of trees, global warming, natural disasters	Modelling and enquiry based learning	Need some more attention on the specific task (climate change)
14) (1/7)	Local environment. Recycling. Waste management/composting.	Personal readings, face to face ED SOSE, ED Sustainability subject was poorly organized and not informative.	Topics more specific to our region.
15) (1/7)	Positioning on earth - northern/southern hemisphere + equator, environmental history of an area - animals + plants. Changes in environment - introduction of non-local species.	Research activities. Excursions/Outdoor investigations.	I feel I am well-informed on basic concepts for ECE.
16) (1/7)	Sustainability - in particular water conservation and looking after resources. Local environment - e.g. Great Barrier Reef, Daintree	Research activities with students on practical experience. Inquiry units within schools. Online videos.	Planning - units and lessons, how to incorporate into programs. I studied sustainability in first year - feel this could have been split into 1st and then 4th year due to content and changes to content.
17) (0/7)	Use only what you need. Recycle/up cycle	The sustainability subject which was undertaken in the first year; has not been heavily implemented across the degree, which is disappointing.	Nothing offered

Table 6 Responses to open questions 6, 7, and 8 (Fourth Year) by top and low scoring PSTs

A comparison of the two groups of PSTs by knowledge score suggests that personal interest was key to engagement with climate change education. This seemed to be associated with active involvement in implementing sustainability units through professional experience. This raises a question: how much do schools emphasise sustainability in their programs? How often do PSTs see sustainability topics taught on practicum? Surely this matter must be urgently investigated. PSTs who scored higher on the knowledge section made suggestions of pertinent subject areas for their future students (Q6). One of these PSTs (number 2) appears to believe that a balanced view of the issue needs to be presented to students since she mentions "*Natural climate changes and effects*" as being part of what needs to be taught to her future pupils. Such a position has been noted before in research (Cotton 2006a; 2006b). This perspective involves presenting students with 'both sides of the climate change argument' or a balanced perspective, and has been identified by teachers as important in climate change education (Cotton 2006a; 2006b) because they feel strongly that they should try to avoid influencing students' attitudes, or imposing any kind of pro-environmental agenda. Of particular interest was the comment of one of the PSTs (number 5) who stated that the source of her knowledge was "*The uni subject where we had to actually implement a sustainability unit. Though we were also given the opportunity to just volunteer at an organisation and pretty much was a waste of time".* This strongly suggests that a requirement to construct a unit implementing learning for sustainability rather than simply volunteering to support sustainability in a community which was an assessment requirement of the fourth year subject might be a more effective way to raise engagement with climate change education and to ensure that learning about climate change is not superficial or ephemeral.

Those who scored 0 or 1 in the knowledge section were more divergent in their responses indicating a range of views. Once again a "balanced" view emerged (number 8) in relation to teaching future students, while a focus on local issues was strong in relation to teaching future pupils and addressing personal gaps in knowledge. Of interest were two responses in this group of low scoring PSTs which indicated that both PSTs believed they knew enough for their needs, and would do research independently as and when needed for their teaching. Such responses mirror prior findings in relation to teacher beliefs and their strong influence on pedagogy (Cotton 2006b) but nonetheless they raise important questions and require investigation. For example, how frequently do practicing teachers actually investigate and research topics which they are unfamiliar with like climate change so that they can construct meaningful units for their students? If this is a common and fruitful practice among practicing teachers then perhaps tertiary curricula need not spend time on them. This group also voiced a need for pedagogical strategies for implementing sustainability which corroborates their underlying gaps in the underpinning knowledge and contrasts with the responses of those PSTs who had high knowledge scores. Importantly two of these low scoring PSTs also critiqued the way the sustainability subjects were organised and pointed to lack of integration of sustainability across the degree program.

Overall, results suggest that most of the 87 PSTs were, by their own admission, not well equipped to teach their future students about climate change. The reasons for this seem to include an implicit lack of understanding of the underpinning science, its impacts and/ or mitigation and adaptation actions that are necessary for pro-environmental action (Anderson, 2012) and a leaning towards a belief for a "balanced' view of climate change. The media was a strong element in their sources of knowledge (and possibly beliefs). Yet this appears to be at odds with their responses on the attitudinal questions where they endorsed a strong belief and confidence in their capacity as teachers to influence students' pro-environmental attitudes and help solve environmental problems.

Discussion

Despite the inclusion of two semester-long subjects specifically focused on sustainability and a science pedagogy subject, no relationship between measured knowledge of basic climate change science and confidence to teach about the environment in this sample of PSTs, recalling prior findings in Australia (Effeney & Davis, 2013). Their high level of confidence even extended to the belief that they would be able to include an environmental focus in their teaching despite the fact that in some cases their measured baseline knowledge actually decreased between the first year and fourth year of the B.Ed. program. This might be explained by retroactive interference (Howe, 2004), new learning diluting science previously learnt at school, such as the greenhouse effect, photosynthesis and respiration and the like. Or the lack of association might indicate that the questions used to assess their knowledge were in a format that did not trigger the correct memory. Alternatively it is possible that they did not pay attention to the issues relating to climate change *per se* but instead focussed on other topics included in their study of sustainability.

The lack of relationship between measured knowledge and confidence might indicate they do not feel constrained by their lack of knowledge; they do not believe that climate change per se is important or are perhaps unaware of their actual knowledge. Dunning, Johnson, Ehrlinger and Kruger, (2003) suggest that perhaps they have an inflated perception of their own abilities, although their responses to questions asking to name gaps in their content and pedagogy indicate that they are, mostly, aware of their limitations. Tertiary student over-optimism has been identified as a significant contributor to academic failure in at university (Haynes et al., 2006) and this effect might be implicated here too. Results here are of particular concern since these PSTs studied two subjects designed to embed sustainability and such issues as climate change, as well as a science pedagogy subject, and in addition were exposed to university-wide cultural norms which put a strong emphasis on climate change and sustainability issues. However, another possible reason for low knowledge levels is the conceptual difficulty of climate change science with its interdisciplinary nature drawing as it does from chemistry, physics, biology and earth sciences. Given that these PST candidates did not need a senior science high school subject to enter the B.Ed. program, unless they were planning to train as secondary science teachers, this also compounds the low knowledge levels results found in this study, though it does not explain the decline in knowledge from initial entry to final year.

One explanation for the results of this study might be connected with the actual pedagogy of the tertiary educators of these PSTs. It is difficult to know to what extent university educators have adopted a "balanced" view (Cotton 2006a) when presenting materials to PSTs in relation to climate change and sustainability despite the university's pro-environmental pro-climate change stance. Bronfenbrenner's theory which posits that influences from the extended social environment filter down to influence beliefs and attitudes certainly appears to hold some of the answers for these study results since many cited the media as sources of their knowledge, an influence from the exosystem and macrosystem. The media has, up until most recent times, presented a "balanced" view of climate change science, with a focus on reporting climate change sceptics' perspectives on climate change as if they represented 50% of the scientific consensus on the subject instead of their actual 5% proportion.

When teachers enter the classrooms in Australia they will need to address the broad area of sustainability, a cross-curriculum priority in the Australian Curriculum, embedded in all learning areas. The curriculum includes a strand called Science as a Human Endeavour, which requires students to consider the nature and influence of science on people. For example, 'using science knowledge to evaluate whether they should accept claims, explanations or predictions' (ACARA, 2014). As a result of these contingencies, the knowledge and pedagogical skills to teach sustainability topics and attendant topics like climate change will need to be embedded in

all areas of pre-service teacher training. In the university in which this study was undertaken, there has been a strong focus in expanding sustainability beyond single core subjects to a wider and more structured approach across the whole B.Ed. course, as one of the PSTs in the study suggested. However, to what extent this has actually been accomplished within the various subjects/courses is at present unknown and must be investigated in future research. Similarly, results of this study need to be replicated both in this university and in other universities before the design of the B.Ed., in terms of content and instructional style is adjusted to better prepare future PSTs to teach sustainability topics. If it is found that courses on sustainability topics make no appreciable difference to PSTs' engagement and learning across the higher education sector then research must identify which factors impede and which factors promote the learning process so that courses are designed and delivered in ways that make a difference. Sustainability topics cannot be omitted from school curricula as we move into a future that is predicted to be even more challenging due to problems arising from overpopulation and climate change. Future generations of children need to understand how to mitigate and adapt to contingencies that are set to take place in the not too distant future (IPCC, 2012).

It is possible that PSTs would respond better to different teaching approaches to learn about climate change than those employed at this university thus far. Bunten and Dawson (2014) argued that it should be taught by enquiry rather than through transmission. Responses in this study included sources of knowledge that emanated from enquiry based and research based activities, yet these sources did not lead to high PST knowledge scores. PSTs further repeatedly stressed they wanted to know more about mitigation actions, solutions and human impacts of climate change, areas less abstract and more clearly connected to their everyday life. This cohort's responses reflected prior findings. For example, Anderson (2012) reviewed the literature with a specific goal to improve PSTs' ability to educate about climate change. Anderson (2012) recommended that PSTs should be taught the history and causes of climate change, mitigation and adaptation practices, and the positions and understanding of different interest groups that shape responses to climate change; PSTs should also be given time to develop their ability to critically evaluate these responses.

Implications

Prof Vaille Dawson advocated that climate change should be taught to all students starting from primary school and be embedded in a range of subjects (Arup & Priess, 2014). It is one of the most serious challenges that faces humanity and as such teachers must have the capacity to prepare their students to understand its implications and impacts so that they can adapt in a world that is very likely to be much more challenging that it is at present (Dawson, 2015). But despite at least this case study university's endeavour to include climate change science and a sustainability focus into the B.Ed. curriculum, basic science and climate change education concepts appear to remain elusive to PSTs.

In order for a school curriculum which promotes understanding of climate science and pro-environmental behaviour to be successful, teachers need to be very adroit in providing practical activities that can illustrate climate change science, be aware of common alternative conceptions (their own included) and be given the resources and skills to overcome them. Cullen (2010) claimed that teachers of all levels should develop in their students an understanding of the connection between fossil fuel burning, heat-trapping carbon dioxide and climate change impacts so that their level of concern is raised to take mitigation actions.

As has been noted before knowledge alone is not sufficient to change behaviours, but is a necessary prerequisite. Climate change science has been highly politicized and misrepresented in the media, the main source of PSTs knowledge according to results of this study. Future and

practicing teachers need to understand the difference between appropriate scientific scepticism and denial of climate change. Lambert and Bleicher (2013) stressed that to help PSTs to comprehend and teach about climate change, it must be framed in such a way as to enable them to construct their own knowledge. To be effective such framing depends on knowing the expectations, beliefs, and prior knowledge of the audience. Perhaps all environmental education for PSTs needs to be based in the first instance on a detailed understanding of their prior beliefs and knowledge, particularly for such a politicised, challenging and emotive topic as climate change.

Science educators and education researchers have argued that socio-scientific issues ought to be used as contexts for learning science for a long time (Dawson, 2015). Such an approach would lead to convergence between science education and environmental education (Wals, Brody, Dillon & Stevenson, 2014). In 2014 the case was made for the shared purposes of science educators and environmental educators (also read 'educators for sustainability') to engage people in addressing our socio-scientific, sustainability challenges. Wals, Brody, Dillon and Stevenson, (2014) argued that science education with its focus on teaching knowledge and skills, and environmental education which stresses the incorporation of values and pro-environmental behaviour, have become increasingly disconnected. They cite examples of the natural sciences and environmental education which, when taught separately, give a disjointed answer to society's demands for a sustainable society. They made a strong case for the convergence of science education and environmental education, noting that without linkage with the sciences, environmental education will not be able to find responsible and realistic ways of dealing with the contradictions and uncertainties raised in scientific debates surrounding questions of sustainability. Certainly some responses from this study echo the need for a greater science focus to enhance PSTs understanding of climate change. One answer to this disconnect is to use climate change as an overarching theme since it can provide an authentic linkage through its inherent socio-scientific dimensions for teaching students of all ages a wide range of science, geography and history concepts. These include the atmosphere and its structure, chemistry and physics, the oceans and their chemistry and physics, the biology of living things, including respiration and photosynthesis as well as ecological systems, the carbon, nitrogen and water cycles, and food webs and the effects of perturbations (due to climate change) on these. Earth and space science can also be linked to climate change, as well as concepts of sustainable development, human diseases, diet, pollution, energy requirements and the ethical dimensions of resources and human population growth. At tertiary level, climate change as a theme has the potential to be used as an authentic context for teaching education for sustainability to PSTs.

In moving forward to support PSTs to effectively grapple with climate change and enable them to teach it to their students the process of providing a 'balanced' view of climate change science (Cotton 2006a) must be explored in tertiary settings. This very approach might be leading PSTs to turn to the media for their sources of knowledge about climate change. Results from a European study (Torkar 2013) on the views of PSTs and other university students showed that they expect their lecturers to promote the principles of sustainable development. The majority considered unacceptable any lecturer's statement that would cast doubt on the cause or the necessity to act against climate change. Moreover, research needs to look at the barriers which prevent PSTs from engaging with climate change science, and if these influence different cohorts of PSTs: males, females, those from regional and/or remote or metropolitan locations, more mature entrants to the program, Indigenous candidates and so on. To address a limitation of this study PSTs' perceived influences on their beliefs about climate change need to be explored to assess Bronfenbrenner's theory (1979) which proposes that influences upon one's attitudes arise from diverse places. Such research could help to inform the design of future B.Ed. courses on sustainability topics.

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Appendix A

COMPLETION OF THIS SURVEY IMPLIES CONSENT

Education for Sustainability: Supporting pre-service teachers Anonymous 4th Year Survey

This survey aims to help support beginning teachers in the area of education for sustainability. Your responses to this survey will in no way affect your assessment. They will remain confidential to be seen only by the research team. The answers you provide will be used to improve the way we teach the topics embedded in sustainability for education. Your contribution to this research is greatly valued. Thank you.

Part A. Please provide the following information by ticking (✓) the appropriate box:

Age: 20-25 ☐ 26 + ☐
Gender: M ☐ F ☐
Specialist Area ECE ☐ PRI ☐

Please respond to the following questions by ticking (✓) the appropriate box:

		Strongly agree	**Agree**	**Disagree**	**Strongly Disagree**
1)	I am confident that I can prepare accurate teaching modules about our environment for the students that I will be teaching				
2)	I cannot include education for our environment in my teaching because it should be taught by specially trained teachers				
3)	As a teacher I can play an important role in solving environmental problems through teaching				
4)	It is very important to educate school students about our environment from an early age				
5)	I do not believe that there is enough time in the curriculum to fit in education for the environment as well as everything else we must teach				

6. Please write in the space below the **specific topics within subject area**(s) your students should know and understand in order to make informed decisions about climate change **mitigation** and **adaptation** for the future.

_____
_____
_____
_____
_____

7. Please indicate **the main sources** of your knowledge about environmental education and climate change **in as much detail as you can**, including the **types of teaching pedagogy** that you found most engaging for these subject areas; e.g. online tutorials, face to face lectures, research activities. Your answers might include personal interest, study courses, practical school experiences, the internet, university teaching or media sources. If you have had no formal education for these subject areas please tell us.

_____
_____
_____
_____
_____
_____
_____

8. Please indicate any **gaps in your content and pedagogy knowledge** for climate change education that you think future pre-service teachers need to be taught in order to be able to meet their teaching obligations for sustainability and climate change education. Any **other comments** you have are also most welcome.

_____
_____
_____
_____
_____
_____

Part B.

Please circle the answer you think is most appropriate in each question below.

1. Climate Change is caused by…
   a) a hole in the earth's atmosphere
   b) natural climate fluctuations
   c) increased cloud cover
   d) increased carbon emissions
   e) solar activity
2. The ozone layer has been mainly depleted by…
   a) burning of fossil fuels
   b) pollution from garbage tips
   c) the release of CFC's into the atmosphere
   d) the increasing temperature of the sun's rays
3. The biggest environmental threat to Australian farmland as a result of climate change is …
   a) soil salinity
   b) land clearing
   c) drought
   d) pesticides
4. Some water, a small amount of soil, a few green aquatic plants and a fish were placed in a large bottle. The bottle was sealed to prevent the exchange of gases and other materials between its contents and the outside. The bottle was placed in a window to receive light during the daytime. Is carbon dioxide produced by the plants?
   a) Yes, but it is produced only at night when the plants can no longer carry on photosynthesis.
   b) Yes, it is produced all the time as a result of cellular respiration.
   c) No, it is a waste product of animals only.
   d) No, plants take in only the waste products exhaled by animals.
   e) No, plants only produce oxygen
5. Greenhouse gases in the lower atmosphere (troposphere) absorb:
   a) incoming ultraviolet radiation
   b) infrared radiation emitted by the earth's land surfaces and oceans
   c) incoming solar radiation reflected by clouds
   d) incoming solar radiation across the entire electromagnetic spectrum
6. The major source of anthropogenic carbon emissions comes from:
   a) using coal to generate electricity
   b) burning fossil fuels, industrial processes
   c) increased run-off of nutrients from farmland
   d) increased populations of animals and humans breathing out carbon dioxide and producing methane gas
7. The major human impact on the water cycle is:
   a) increasing population breathing out more carbon dioxide and water vapour
   b) acidifying rain water by the burning of fossil fuels
   c) run off from industry, agriculture and sewage which dissolve in water and pollutes it
   d) humans do not have an impact on the water cycle; it is governed by the sun's energy, circulating it through its phases
   e) over use causing water to run out