Pre-Service Teachers' Preparedness for Sustainability Education - A Case Study

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Abstract
Teacher education is a vital first step in embedding education for sustainability in Australian schools (Australian Government, 2009). Research indicates that tertiary programs for teachers do little to prepare teachers for teaching education for sustainability (Ferreira, Ryan & Tilbury, 2007; Tilbury & Cooke, 2005).

Within this nationwide context, the School of Education at James Cook University is focusing on embedding sustainability across the curriculum in Bachelor of Education courses. A foundational sustainability subject is being offered for the first time in 2010. This subject provides an introduction to principles and practices of sustainability education, highlighting interrelationships between topics related to climate change, energy, water and biodiversity.

The aim of the report here was to ascertain first year Bachelor of Education students' level of knowledge of issues underpinning sustainability, using a questionnaire based on prior research (Taylor, Kennelly, Jenkins & Callingham, 2006) and the PISA international survey of secondary students' environmental and geophysical science knowledge (OECD, 2006).

Using descriptive and inferential statistics, results indicate that this sample of 155 first year pre-service teachers report similar awareness of relevant sustainability issues compared to the fifteen-year-old Australians surveyed by OECD (2009). Results were not significantly different for age group (17-19, 20-26 or 26+ years) although there were some significant differences by gender. Performance in the knowledge questions of the survey showed some interesting variations by question and age group, indicating perhaps a range of influences and exposure to learning activities. These are compared to previous studies' findings.

While the results of this study are primarily intended to inform and support the initiative to embed sustainability education across the Bachelor of Education degree at James Cook University, they might hold wider relevance for those interested in the process of embedding sustainability in pre-service teacher programs nationally.

Keywords: Sustainability, Education, Pre-Service Teachers, First Year Experience

Sustainability in Higher Education

Higher education has been positioned to play a critical role in fulfilling the goals of the UN Decade of Education for Sustainable Development (DESD). As we cross the mid-point of the nominated decade, it would seem that Education for Sustainable Development (ESD) is gathering momentum in the university education sector both internationally & nationally (see, for example, Dawe, Jucker & Martin, 2005, Shephard, 2010). This movement has been facilitated by the development of several initiatives aimed specifically at the tertiary sector including the well-recognised "Talloires Declaration of University Leaders for a Sustainable Future" (Thomas & Nicita, 2002). Universities are subject to particular scrutiny in relation to how they fulfil their role outlined by UNESCO in relation to the training of pre-service teachers (UNESCO, 2005).

Sustainability and Teacher Education

Pre-service teacher training in relation to sustainability education appears to be slightly ad hoc, whether internationally or nationally (see, for example, Elshof, 2005; Holden & Hicks, 2006; Spiropoulou, Antonakaki, Kontaxaki & Bouras, 2007). This might be due to the newness (and ambiguity, according to some authors) of conceptualisation of Education for Sustainability (EfS) and its emergence from the disciplinary area of Environmental Education. In Australia, Environmental Education has not traditionally been a pre-requisite for primary teachers and a matter of choice for secondary specialists. Concepts related to sustainability are often subsumed under larger disciplinary areas and might include environmental science topics within a particular science discipline or matters of justice and equity in relation to studies of society and environment. As such, it is likely that primary and early childhood teachers graduate with minimal exposure to sustainability education, while secondary teachers might graduate with nil exposure to sustainability education.

Recent research has demonstrated that this to be the case. Cutter-McKenzie & 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 reported concern with the level of understanding of sustainability concepts in the teacher population overall. This is worrying on many levels but particularly in light of the OECD 'Green at Fifteen' paper which indicates that there remains much teaching scope to improve young people's skills in relation to dealing with complex environmental issues and that this would be of particular usefulness to young people from disadvantaged backgrounds. It is hard to imagine that a teacher identified as ecologically illiterate is able to create an environmentally competent generation of young people.It is important to note, however, that in addition to minimal pre-service training, EfS has not historically played a prominent role in curriculum and planning documents that serve as tools to guide teachers. It is only recently that EfS has reached prominence through inclusion as a cross-curricular theme in the new draft National Curriculum (following a similar earlier innovation in the UK) and in national and state initiatives related to Sustainable Schools (see, for example, AuSSI, QESSI, 2010).

Studies have explored the constraints faced by practicing teachers in implementing sustainability orientated programs in schools and these have variously been identified as including the pressure of an over-crowded curriculum, prioritization of literacy and numeracy over other subject areas in the primary context, tight disciplinary boundaries in the secondary context and a lack of pedagogical content knowledge as it relates to sustainability education (Robinson & Crowther, 2001; Cutter-Mackenzie & Smith, 2003; Taylor, Nathan & Coll, 2003). While pre-service teacher programs may have limited scope to address some of the broader structural constraints that impede effective delivery of sustainability education, they are well-situated to address issues related to awareness and improvement in levels of pedagogical content knowledge.

Professional Teaching Competencies in Relation to Sustainability

There is some debate about the particular set of cognitive skills and affective attributes that combine to create an effective teacher of education for sustainability (EfS). Defining appropriate graduate attributes will imaginably be one of the key challenges of implementing pre-service teacher programs with a new emphasis on EfS. While there is considerable literature exploring the affective elements of EfS, particularly in relation to values and motivation (see, for example, Bussey, 2008; Fien, 2003; Jurin & Fornter, 2002), this paper focuses primarily on the cognitive component of EfS due to the small-scale nature of the case study reported. Accordingly, this study focuses on the first two objectives of the Tbilis

Declaration related to learning for a sustainable environment, namely that of Awareness and Knowledge (UNESCO-UNEP, 1978, cited in Fien & Tilbury, 1996, p.14).

Awareness & Knowledge

> *If teachers are to engage their students effectively in EfS, it is a reasonable assumption that they should have an understanding of EfS as a concept and a secure knowledge of key contemporary environmental issues (Taylor, Kenelly, Jenkins & Callingham, 2006, p.47).*

The authors' statement relates to Cutter-McKenzie & Smith's work (2003) which discussed the problematic nature of knowledge promulgation in education generally and, more specifically, education orientated towards sustainability. Their research demonstrated teachers' perceptions that content knowledge was of less value than the ability to 'access knowledge' which resulted in a teaching emphasis on values and attitudes as they relate to sustainability rather than knowledge. The authors make the link between this teaching emphasis and historical progression within the discipline of education from promotion of a 'transmission' pedagogical approach to one of 'facilitation' (Cutter-McKenzie & Smith, 2003).

These findings point to two key problems that exist not only in the context of sustainability education but also in the wider field of science education teaching in general. The first is that of misconceptions related to key conceptual understandings of established disciplinary knowledge that often remain unchecked at the professional level and are in fact promulgated through the process of teaching and learning. Spiropoulou et al (2007) refer to a large number of studies demonstrating teacher (and student) misconceptions on science topics and environmental issues with particular reference to problems in discrimination between weather and climate, global warming and ozone depletion and air and water pollution. Recent work by Boon (2010) with both secondary students and pre-service teachers has demonstrated similar confusion around the concepts of global warming and ozone depletion. It is then of no surprise that surveys of the general population highlight a similar lack of understanding, causing authors such as Robinson & Crowther to bemoan that 'knowledge of the environment seems rather dismal even among educated people' (2001, p.14).

The second issue of concern, as highlighted in Cutter-McKenzie and Smith's work, is the tendency for teachers to de-emphasize subject areas they are less confident with. A similar situation again occurs in primary science education where a recognized lack of pedagogical content knowledge has resulted in teachers spending only 5% of classroom time on science instruction (Masters, 2009). In the Queensland context, educators have had considerable freedom to choose the topics that they teach and participants from the Cutter-McKenzie & Smith's study indeed indicated that 'personal choice' dictates what is taught. As the National Curriculum is introduced this might change. Until such time pre-service teachers must be prepared to develop a strong content and pedagogical knowledge base in relation to EfS to ensure they have can implement a curriculum with an appropriate sustainability orientation. If the endpoint of sustainability education is a citizenry capable of 'informed decision-making', teacher education programs have a critical role to play in ensuring that graduate teachers are indeed informed.

Methods

Ethics clearance was obtained prior to administering an anonymous survey to pre-service teachers. The survey instrument[1] included demographic questions, items assessing perceptions of knowledge and actual knowledge of content examining subject matter classified under three domains of sustainability education as described by OECD (2009) (p.20): living systems, earth and space systems and physical systems. The survey was distributed to pre-service teachers during a lecture and was made available electronically to those studying early childhood education off campus.

The response rate from the face to face survey administration varied by campus: in Townsville the response rate was 52.7%, in Cairns it was 17.9%. Early childhood specialists (ECE) studying off-campus sent their survey via email to the research assistant to maintain anonymity; their response rate was 15.6%. All analyses were performed using the PASW statistical package.

Notwithstanding the low response rates which might suggest a disengagement from issues of sustainability or fear of poor performance, or both, there is some valuable data emanating from the survey to inform tertiary education programs in embedding sustainability education.

Results

Table 1 shows the demographic characteristics of participants. Of a total of 156 participants 6 omitted to state their specialist area.

Table 1 Pre-service teacher specialist areas, gender, age and attendance campus

		Specialist Area					
		Early Childhood Education (ECE)		Primary (PRI)		Secondary (SEC)	
		N = 32	%	N = 65	%	N = 53	%
AGE	17-19	14	43.8	40	61.5	37	69.8
	20-25	4	12.5	10	15.4	12	22.6
	26+	14	43.8	15	23.1	4	7.5
GENDER	male	1	3.1	7	10.8	22	41.5
	female	31	96.9	58	89.2	31	58.5
CAMPUS	Townsville	26	81.3	53	81.5	46	86.8
	Cairns	6	18.8	12	18.5	7	13.2

Following the rationale of the OECD (2009) study which assessed student knowledge and understanding of environmental science and geoscience, we asked pre-service teachers to rate their knowledge about: Greenhouse gases, Nuclear waste, Forests clearing and Water shortages on a four point scale ranging from (1) "I have never heard of this" , to (2) "I have heard about this but I would not be able to explain what it is really about", to (3) "I know something about this and could explain the general issue" and (4) "I am familiar with this and I would be able to explain this well". Results of these questions are summarised in Table 2.

[1] A copy of the survey instrument can be obtained from the authors.

Table 2 Perceived familiarity with selected environmental issues

Environmental issue		Gender		Specialist area			Age		
		MALE	FEMALE	ECE	PRI	SEC	17-19	20-25	26+
		%	%	%	%	%	%	%	%
Greenhouse gases	never heard of it	.0	.0	.0	.0	.0	.0	.0	.0
	heard about it	12.5	23.0	19.4	21.9	17.0	21.3	26.9	14.7
	know something and can explain general issue (3)	56.3	55.7	64.5	51.6	58.5	55.3	46.2	64.7
	familiar and can explain (4)	31.3	21.3	16.1	26.6	24.5	23.4	26.9	20.6
	Total (3 and 4) (OECD 72%)	*87.6*	*77.0*	*80.6*	*78.2*	*82.5*	*78.7*	*73.1*	*85.3*
Nuclear waste	never heard of it	.0	.0	.0	.0	.0	.0	.0	.0
	heard about it	25.0	46.7	48.4	43.8	35.8	43.6	46.2	35.3
	know something and can explain general issue (3)	59.4	43.4	45.2	40.6	54.7	45.7	46.2	50.0
	familiar and can explain (4)	15.6	9.8	6.5	15.6	9.4	10.6	7.7	14.7
	Total (3 and 4) (OECD 53%)	*74.0*	*53.2*	*51.7*	*56.2*	*64.1*	*55.3*	*53.9*	*64.7*
Forest clearing	never heard of it	.0	.8	.0	1.6	.0	1.1	.0	.0
	heard about it	15.6	13.1	12.9	9.4	15.1	13.8	15.4	11.8
	know something and can explain general issue (3)	53.1	57.4	51.6	57.8	58.5	54.3	65.4	55.9
	familiar and can explain (4)	31.3	28.7	35.5	31.3	26.4	30.9	19.2	32.4
	Total (3 and 4) (OECD 80%)	*84.4*	*86.1*	*87.1*	*89.1*	*84.9*	*85.2*	*84.6*	*88.3*
Water shortages	never heard of it	.0	.0	.0	.0	.0	.0	.0	.0
	heard about it	15.6	11.5	16.1	9.4	11.3	11.7	15.4	11.8
	know something and can explain general issue (3)	56.3	53.3	41.9	54.7	58.5	56.4	50.0	50.0
	familiar and can explain (4)	28.1	35.2	41.9	35.9	30.2	31.9	34.6	38.2
	Total (3 and 4) (OECD 98%)	*84.4*	*88.5*	*83.8*	*90.6*	*88.7*	*88.3*	*84.6*	*88.2*

Tests of analysis of variance (ANOVA) showed there were no significant differences between the three different specialist groups or by age in relation to their perceived knowledge about environmental issues. There was one significant difference between males and females, and that was in relation to their declared awareness to nuclear waste issues with females having a lower mean than males ($F(1,153) = 4.5$, $p < .05$).

A comparison of these results with the results obtained by OECD (2009) for the same questions answered by Australian fifteen year olds shows that this group of pre-service teachers' perception of awareness of these issues reflects similar trends as those stated by fifteen year old Australian students. On average, the pre-service teachers report a greater awareness of these issues, except in relation to water shortages which are significantly lower than those of the secondary students. (The percentage of Australian fifteen year old students

who report that they are familiar with or know something about the above environmental issues is listed in brackets in Table 2.)
The next analysis examined the actual knowledge of respondents as indicated by the survey results. Results are tabulated in Table 3.

Table 3 Mean scores of knowledge results

Student scores (N= 156)	Mean	Maximum	Mode	Minimum
Knowledge score (Maximum marks possible 21)	9.73	16.00	11.00	.00
Nuclear energy / Physical systems (Maximum marks possible 3)	.96	3.00	.00	.00
Earth and Space systems (Maximum marks possible 5)	1.82	4.00	2.00	.00
Living Systems (Maximum marks possible 13)	6.95	12.00	9.00	.00

The top mark gained for overall knowledge was 16 out of a possible 21, the most frequently occurring mark being 11. When the marks are decomposed to examine the different subsections of the test it is evident that questions based on Living Systems were more likely to be correctly answered while those based on Earth and Space systems and Physical systems were poorly answered. Rates of correct responses to each question are shown in Table 4.
It is important to note that questions which were based on understanding and processing of (science)concepts, such as the water cycle, element cycling, photosynthesis, nuclear waste disposal and power generation, forest clearing, the greenhouse effect and the ozone layer were more poorly answered than those questions which could be answered by extracting memorised facts. Indeed, the question on climate change was correctly answered by 76.9% of respondents while the one on greenhouse gases was correctly answered by only 26.8%, indicating perhaps an engagement with the current media climate change debate but not a clear grasp of the greenhouse effect.

This level of engagement with issues is also evident in the way questions about nuclear power and waste disposal were answered. While respondents knew which initial starting material would produce nuclear waste when used for power generation (62.5% correct), they were not clear how to effectively dispose nuclear waste (20% correct) or the nuances of nuclear power generation and its ramifications (46.5%).

Analyses of variance (ANOVA) were conducted to see if there were any score differences between the various sub-groups of respondents. No significant differences were found between different specialists or between gender and knowledge, but there was a significant difference between those who were 20 years old and over compared to those 17-19 years old, ($F(2, 154) = 3.8$, $p < 0.05$), the older cohort having a higher mean knowledge score (9.1 compared to 10.9). These scores might reflect a higher engagement with environmental issues or a different exposure to these concepts at school. However, without further information it is difficult to be sure what such a difference might be due to.

Table 4 Percent correct responses to survey knowledge questions

Survey questions	Correct answers (%)
Sustainable development means…	74.3
The biodiversity crisis refers to a decrease in …	69.0
Climate Change is caused by…	76.9
The MAIN cause of water pollution in the ocean and rivers is…	76.2
The ozone layer has been mainly depleted by…	50.0
The biggest environmental threat to Australian farmland as a result of climate change is …	63.6
Water shortages are caused in Australia because:	50.0
The MOST COMMON reason an animal species becomes extinct is…	84.5
The current worldwide reduction in the number of ocean fish is mainly due to:	41.0
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?	50.0
Symptoms of water scarcity are:	89.5
Greenhouse gases in the lower atmosphere (troposphere) absorb:	26.8
Which of the following (cycles) is not affected by the clearing of forests:	27.3
The major source of anthropogenic carbon emissions comes from:	48.9
The number of plants and animals able to live in a place is restricted by:	73.4
The major human impact on the water cycle is:	6.5
Tropical rain forests are important because:	72.5
Nuclear waste (disposal) …	20.0
Which is the LEAST VALID reason to support the statement: "We must limit the clearing of tropical rainforests…"	36.5
Nuclear power generation is:	46.5
Which one of the following, when used in power plants for electricity generation, results in nuclear waste?	62.5

A final analysis was conducted to examine if respondents' declared perceptions of their knowledge of environmental issues predicted their actual knowledge of questions on the survey pertaining to these. Regressions were conducted to test whether the participants' declared knowledge of these issues (Table 2) predicted their actual knowledge on the survey. Results showed that the model could not significantly predict knowledge scores, indicating that although participants were confident that they knew about the above environmental issues, overall their actual knowledge did not match their confidence.

Discussion

The results of this small case study offer some interesting points for curriculum designers in teacher training institutions interested in embedding EfS for trainee teachers.

First, the poor response rate for the survey might indicate that engagement with issues of sustainability are low and a course needs to be set in place early in teacher training institutions, designed to heighten pre-service teachers' awareness, value and knowledge of EfS. This is critical in the face of current global environmental stresses, a pragmatic issue, as well as to fulfil the aims declared by UNESCO (2005), wherein the teacher's role is of paramount importance to support sustainability education and sustainable development.

Second, the relative lack of understanding of environmental issues shown in the reported results, confirming others' earlier findings (Cutter-McKenzie & Smith, 2003; Taylor, Kennelly, Jenkins & Callingham, 2006), needs to be addressed so that teachers are better equipped to guide their students to knowledge, understanding and behaviours that support sustainable development. There was an apparent confidence declared about environmental issues in this cohort, matching or surpassing that declared by fifteen year olds in Australia (OECD, 2009). Whilst one might deem this to be a positive attribute, it could also be a block to further learning to improve understanding of vital issues.

In order for teachers to guide their students to effectively ponder and debate issues that not only impact upon their ability to fully engage in effective citizenship but also modify their everyday behaviour, students need to be *schooled* in collaborative critical discourse (Osborne, 2010) which must be fully guided by teachers who, themselves, have secure knowledge and understanding of the subject matter and methods of argumentation. In short they need to know what is wrong as well as what is right and that is only going to be possible for students if their teachers are not only fully conversant with the best pedagogies available to engage students but also with the relevant bodies of knowledge. Of course this applies to tertiary teachers as well as school teachers at all levels. Issues of available teaching time in tertiary institutions to fulfil the requirements of each area of need, numeracy, literacy, scientific literacy, embedding sustainability, Indigenous cultural perspectives as well as matters of pedagogy, educational psychology and sociology all compete fiercely. However, if sustainability matters and the science and social science underpinning their understandings are not addressed then educators are not only failing their current students but also future generations.

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