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IDEOLOGY, EPISTEMOLOGY AND PEDAGOGY: BARRIERS AND DRIVERS TO EDUCATION FOR SUSTAINABILITY IN SCIENCE EDUCATION

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Abstract. *The Brundtland Report (Brundtland Report, cited in United Nations Department of Economic and Social Affairs, 1999) definition of education for sustainability (EfS) allows us to conceptualise sustainability in a number of ways in education, such as ecological sustainability, sociocultural sustainability and, political sustainability. Whilst EfS issues have multi-dimensional meanings, including effects, root causes, change strategies and preferred futures each curriculum area can contribute. This paper focusses on how approaches to science education can contribute to or inhibit EfS, according to what degree it informs understanding of sustainability issues, how it may support values and beliefs underpinning sustainability and how priorities in constructing curricula can influence pedagogy. Epistemology, as conceptions of knowledge associated with science, and ideology, as political influences that shape curricula, can direct approaches to pedagogy, which may or may not support EfS. Examples of approaches to science education that may support EfS are discussed with implications for appropriate pedagogy to support EfS summarised.*

Key words: *epistemology, ideology, pedagogy, science education, sustainability.*

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Introduction

Education for Sustainability (EfS) has high international priority, as demonstrated by UNESCO's (United Nations Educational, Scientific and Cultural Organisation) highlighting of EfS in the United Nations Decade of Education for Sustainable Development (DESD, 2005-2014), which 'seeks to integrate the principles, values, and practices of sustainable development into all aspects of education and learning, in order to address the social, economic, cultural and environmental problems we face in the 21st century' (UNESCO, 2010, p. 1). National and local initiatives are required to support UNESCO's DESD initiative. Some countries have well developed supporting statements, though practice is commonly inconsistent with guidance. For example, Australia's comprehensive national strategy for sustainable living has an aim 'to equip all Australians with knowledge and skills to live sustainably' (Australian Government Department of Environment, Water, heritage and the Arts, 2009, p. 4). The Australian Sustainable Schools Initiative provides a comprehensive strategy for EfS in schools (AuSSI, 2009), whilst the National Curriculum to be initiated in 2011 identifies EfS as a sustainability theme (ACAR, 2010). State governments also have local guidance for implementation of EfS in schools; for example the New South Wales Government provides comprehensive guidance for schools to develop a School Environmental Management Plan (SEMP) to implement EfS through the curriculum, grounds and resources management (NSW Government, 2010).

Although guidance for EfS is in place in many countries, the message is not impacting significantly on lifestyles, which remain unsustainable. Australia, which is broadly typical of developed countries, would require the equivalent of the resources of four planet Earths to maintain average levels of consumption (EPA Victoria, 2010). Greenhouse gas emissions per capita are also among the highest in the world, which is influenced by the federal government's reliance on cheap coal as fuel for power stations,

along with high levels of coal exports, even though solar energy is plentiful renewable energy source. Although sustainability issues, particularly related to climate change, are commonly highlighted in the media, Australia, like all developed countries, has a long way to go to achieve sustainability. In schools, although there is good support for EfS, curriculum and assessment pressures particularly from English and maths at primary school and from general subjects at secondary level tend to relegate EfS to marginal status in many instances (Littledyke, Taylor and Eames, 2009). These trends are consistent with contradictions in guidance and practice for EfS in many countries. The reasons for the contradictions are complex, but an understanding of the barriers that inhibit EfS and drivers that may promote it is an important aspect of EfS if informed action for EfS is to be realised. To contribute to understanding these barriers and drivers, this paper will focus on science education as a significant contributing curriculum area for EfS and how ideological, epistemological and pedagogical factors acting as barriers or drivers can affect how approaches to science education may or may not influence EfS to effect informed action for sustainability.

The Importance and Scope of EfS and the Role of Science Education

We are at a critical, crisis phase of human history in our impact on the environment, as exemplified by a statement from the Union of Concerned Scientists:

> Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms and may so alter the living world that it will be unable to sustain life in the manner that we know. (Union of Concerned Scientists, 1992).

A major issue in the current crisis is climate change associated with observed increase in anthropogenic greenhouse gas concentrations, which are mainly produced from the burning of fossil fuels and from deforestation (Yencken and Henry, 2008). Ackerman and Stanton (2006) indicate possible consequences of different scenarios of increases in global temperatures, which could rise between 1.4 and 5.8º C (2.5 to 10.4º F) by 2100 if present levels of greenhouse gas emissions are maintained (Human Development Report, 2007/08). These possible scenarios range from damaging (such as more extreme weather events with pole-ward migration of plant and animal species and extinctions of less adaptable species, increased tropical diseases, with decreases in crop yields plus communities facing widespread droughts) to catastrophic (such as major decreases in agricultural production with decreasing food supplies, major rises in sea levels causing massive damage to coastal communities and major cities, and a possibility of shut down of the ocean's circulation system removing the crucial currents that warm and stabilize the climate of Northern Europe).

In spite of the potential danger and significant risk from these possible scenarios, most people are unwilling to take appropriate action. For example, Kuckartz (2009) shows from surveys in Europe that many people are sensitive to climate change issues (80-90%), while fewer are knowledgeable (20-50%) but even fewer take personal action to combat the problem (5-20%). We are clearly having major negative impact on the planet and we need urgent action to achieve sustainability, as 'human beings may be ever more sawing off the branch on which it is perched' (Ehrlich and Ehrlich, 2008, p. 206). Effective EfS, leading to positive action to protect the environment is essential to ward off potential catastrophe. However, development of effective EfS requires clear understanding of its scope and influence.

Sustainable development is defined in the 'Brundtland Report', *Our Common Future*, made by the World Commission on Environment and Development in 1987 as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland Report, cited in United Nations Department of Economic and Social Affairs, 1999, p. 1). This definition allows sustainability to be conceptualised in a number of ways to inform EfS:

- 'ecological sustainability – the integrity of ecological systems and diversity are sustained
- economic sustainability – people have livelihoods that are underpinned by appropriate and

sustainable development and resource use
- socio – cultural sustainability – diversity of social and cultural norms and traditions are respected with harmony
- political sustainability – there are societal processes that encourage good governance, social participation, and active citizenship.' (Lang, 2005, p1)

EfS, therefore, must address these four components, which makes it interdisciplinary in nature, though curriculum subject areas have particular parts to play.

Historically, Environmental Education (EE) focussed on maintenance and improvement of the natural environment, which was particularly supported by science education, while EfS has emerged in recent years with a wider focus, being concerned with the development of suitable attitudes, values, practices and behaviours in line with sustainable development across school and all aspects of life contexts. The United Nations Decade of Education for Sustainable Development (DESD, 2005-2014**)** through education aims to instil in individuals:

> … respect for dignity and economic justice for all; respect for the human rights of future generations; accept that economy occurs within the bounds set by ecology and not the other way around. (UNESCO, 2004, p.14)

EfS, therefore, addresses knowledge of the issues, values and attitudes about and behaviour towards sustainability. Before EfS was established, EE, as a precursor to EfS was commonly defined as education: *about* the environment (including cognitive understanding of environmental matters); *in* and *through* the environment (including direct experience of studying and working in the environment); and *for* the environment (as concerned with values and attitudes appropriate to environmental protection) (NCC, 1990). EE included a strong component of science education, particularly ecology and understanding of interactions in ecosystems, ideally experienced in natural settings, alongside investigations into the effects of human activities on the environment. Implicit in this approach was the idea that understanding of issues alongside learning in suitable contexts will lead to individuals taking appropriate actions to support the environment. However, actions are not always linked to knowledge; people do not always act rationally even when consequences are possibly damaging, leading to a contradictory knowledge – action gap (Kollmuss and Agyeman, 2002). How to address this gap is a preoccupation of EfS educators and is an essential issue for achieving sustainability.

It is now generally accepted that EfS requires wider scope than EE to include environmental, socio-cultural, economic and political dimensions of sustainability, though science education continues to play a potentially significant role in EfS in supporting understanding of the issues through scientific perspectives. Approaches and attitudes towards science education are also important to its impact on EfS. Also, an important dimension for EfS is development of critical understanding of how various influences can impact negatively and positively on EfS as a basis for having informed views on what actions are appropriate. Such influences on EfS, can be investigated through analysis of how ideology, epistemology and pedagogy influences learning in school contexts, as values underpinning epistemological assumptions and pedagogy can be linked to affect what happens in schools.

The Interplay between Ideology, Epistemology and Pedagogy in Influencing the Curriculum, Approaches to Science Education and EfS

Figure 1 shows how ideology, as views on the nature and purpose of education, epistemology, as views on the nature of science, and pedagogy, as views on appropriate teaching methods, interact to shape how the curriculum is formed and transacted, which affects EfS directly.

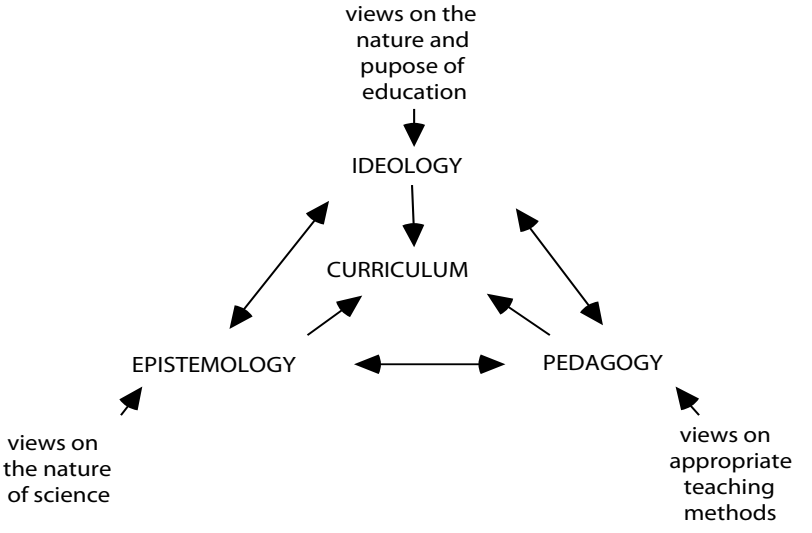

Figure 1: The interplay of ideology, epistemology and pedagogy on the curriculum.

Thus, the curriculum is not value free, and particular ideas can be used to legitimise the ideological values and interests of a dominant group, which can impact on curriculum development and how it is transacted (Bowles and Gintis, 1976). For the purposes of this paper, an ideology can be defined as 'that system of beliefs which gives general direction to the educational policies of those who hold beliefs' (Scrimshaw, 1983, p. 2), while the curriculum can be defined as '...all those activities designed or encouraged within the school's organisational framework to promote the intellectual, personal, social and physical development of its pupils (Morrison and Ridley, 1988, p. 2)'. Epistemological considerations are also significant; as such considerations are central to pedagogy. The development of the curriculum is influenced by the ideological and epistemological assumptions of teachers, school managers, educationalists, curriculum planners, politicians and people in the wider community, which collectively impact on pedagogy.

Epistemological Considerations

The 'project' of modernity has had great influence on how the world is viewed. It came into focus in the eighteenth century through the intellectual efforts of Enlightenment thinkers to develop objective methods of enquiry, as characterised by science, as a means of understanding the universe. Universal morality and law were defined as a way of following its rules, and autonomous art was a way of reflecting its inner harmony and logic. Knowledge was the means to control nature, to remove scarcity and want, and to liberate human thought from the irrationalities of superstition, myth and religion. Harvey described modernity as follows:

Generally perceived as positivistic, technocentric and rationalistic, universal modernism has been identified with the belief in linear progress, absolute truths, the rational planning of ideal social orders, and the standardisation of knowledge and production. (PRECIS 6, quoted in Harvey, 1989, p. 9)

Science was a major influence in the development of modernity, and is a focus of analysis for this paper. Underpinning the modern model of science are assumptions about science as:

- objective
- capable of yielding ultimate truths
- proving things
- having a defined and unique subject matter

- having unique methods
- being value free (Harlen, 1992, p. 2)

This positivist view of science assumes that the word can be independently, objectively and accurately described, that scientists uncover 'truths' about the universe and science education's purpose is to transmit those 'truths'. Many people continue to hold the modern, positivist model of science, as evidenced by draw a scientist activities by pre-service teachers on science education courses, which commonly show the 'egghead scientist', who is typically a lab-coated male, balding, often with spectacles and using test tubes, bunsen burners and other school chemistry equipment. The 'egghead scientist' points to an essentially modern model of science as clinical, abstract, physical, unemotional and reductionist view, as practised by a stereotypical clever, but eccentric and emotionally dysfunctional individual (Littledyke, 2008).

Problems of Objectification through Science

However, as an integral, critical component of EfS, it is important to understand how objectification in modern, positivist science has damaging implications to relationships with nature and to other people. Monod presents objectification as the central tenet of science, and asserts that science depends upon 'the postulate of objectivity' (1972, p. 30). Objectification disengages emotion and ethics, creating the conditions for exploitation and domination, and such objectification has been an all too prominent feature of the way in which science has been applied to the natural environment. For example, Bacon, often regarded as a founder of positivist empiricism, illustrates the power of objectification in his use of images of brutality and force, as were applied in the persecutions of witches, in his scientific approach to nature when he wrote in his *De Dignitate et Augementis Scientarium* (1623):

> The way in which witchcraft, magic, and all superstitions are prosecuted and run aground ... not only sheds useful light on how people accused of such things should be treated, but we can also borrow from it useful directions for unveiling nature's secrets. No one need have scruples about penetrating these caverns and corners when interrogating the truth is his only object. (Cited in Merchant, 1980, p. 168).

In another of his works, *Novum Organum* (1620), he argued:

> The new interrogation method leads to the analysis and dismemberment of nature. The spirit provides the suggestions and the hands do the work. In this way human knowledge and human power are one. (ibid., p. 171).

He encouraged scientists to dominate and subdue nature, to dissect and destroy, if necessary, using mechanistic, reductionist techniques to uncover nature's secret 'truths'. This approach has set the scene for subsequent application of science for over three hundred years.

An example of how objectification can support people in distancing themselves from the damaging effects of their actions is illustrated by Milgram's classic study on 'obedience to authority' (1974), which involved experimental subjects who were instructed to inflict apparent electric shocks on a subject, who was an actor in reality. The aim was supposedly to investigate how learning processes were influenced by negative stimuli, but the real purpose was to see how much pain people would administer under order of a white-coated scientific authority figure. 65% of the subjects were prepared to inflict shocks up to 450 volts (a normally lethal dose) under instruction of the 'researcher', showing that humans have a great capacity for inflicting damage when they absolve themselves of responsibility for their actions. Milgram noted that college students who attended his lectures were aghast at the behaviour of the experimental subjects, though, on being drafted to the military, many performed brutal actions under military order, showing that people are very susceptible to submission to authority and become instruments of its destructive process.

Ecosystems are complex dynamic systems and are sensitive to such objectifying practice with lack

of sensitivity to life components. Hence, objectivist, reductionist approaches to science and technology through 'mechanorphism' (where the natural word is treated like a machine) will damage or destroy the system. Application of such technology, which is based on linear, causal and mechanical thinking, is inappropriate to ecosystems as their dynamic self-regulating systems are incompatible with such interference (Orr 1992).

Objectification also works through discipline practices, which shape behaviour. As Foucault proposed, discipline 'dissociates power from the body ... it reverses the course of the energy, the power that might result from it, and turns it into a relation of strict subjection' (1977, p. 138). Foucault considered that discipline practices, once externalised in public punishments or executions are now internalised more subtly in modern institutions. Training processes for businesses, the police, schools etc. mould pliable minds to particular categories reflecting modern values. In this way, objectivist approaches embedded in the discipline of science can influence how science is expressed, which may account for how a significant number of scientists can readily engage in research that has environmental or socially destructive effects, such as polluting technologies and weapons technology.

Modern, objectivist, positivist science as a discipline has a role in disconnecting from consequences of action. Eagan and Orr (1992) show how modern science within a fragmented, subject-dominated school curriculum reflects values that are alienated from nature. Also interdisciplinary studies, which are essential to understanding the scientific, social, economic and political dimensions of environmental issues in EfS, are very difficult to establish. Such objectification processes are central in modern relationships with the environment. When living things are seen as objects of use or of no consequence, then permission is available to destroy them. When this attitude is also linked with anthropocentrism, where human concerns are seen to be of greatest significance, then this creates potent conditions for environmental exploitation. White (cited in Fox, 1990, p. 7) highlights the essential problems of anthropocentrism as follows:

We deserve our increasing pollution because, according to our structure of values, so many other things have priority over achieving a viable ecology. The problem with our structure of values is that a man-nature dualism is deep rooted in us ... Until it is eradicated not only from our minds but also from our emotions, we shall doubtless be unable to make fundamental changes in our attitudes and actions affecting ecology.

Swimme discusses how modern science has been criticised for supporting positivism, objectification, dualism, reductionism, determinism and mechanism leading to exploitive and destructive practices both socially and ecologically. Whilst modern science has produced undoubted benefits, such as in medical advances, it has contributed to militaristic, patriarchal, anthropocentric and Eurocentric dominance (Swimme, 1988). Thus, modern science has had major social, ethical, technological and environmental impact through its position as the dominant paradigm for some three hundred years, the period of so-called modern era. As many people evidently continue to hold inappropriate modern views science, an important feature of EfS is to challenge and critically understand the process of objectification through modern, positivist science.

Reconstructing Science

A new model of science, which overturned modern science, has emerged in the last hundred years or so. In this model science is conveyed as:

- human endeavour to understand the physical world
- producing knowledge which is tentative, always subject to challenge by further evidence
- building upon, but not accepting uncritically, previous knowledge and understanding
- a social enterprise whose conclusions are often subject to social acceptability
- constrained by values (Harlen, 1992, pp. 2-3)

Discussions from the philosophy of science show that knowledge is seen as having a permanently conjectural (Popper, 1963), and the construction of knowledge takes place in a social context, which

influences that knowledge (Kuhn, 1970; Medawar, 1979). Findings from science also challenge the modern model of science; for example quantum physics shows that matter is inherently unpredictable at a quantum level and cannot be accessed independently of an observer, which destroys the concept of achieving absolute objectivity in engaging with the world (Atkins, 2003). Truth in science is not a fixed concept and ideas about the world can be revised in the light of new evidence. Also, although reductionism through detailed analysis of parts of systems has been significant in science, whole systems can also be influenced by interactions of parts. The field of complexity shows that complex dynamic systems interact in inherently unpredictable ways and produce emergent new forms of order from the interactions (Kaufmann, 1992; Lewin, 1993; Prigogine and Stengers, 1984). Reductionism, a characteristic feature of modern science, is therefore inadequate as a complete method. Furthermore, neurophysiology shows that our brains construct experience of world from sensory input and can adapt physically to changing conditions by responsively developing flexible neural networks (Doidge, 2007), which finally destroys positivism as a finite philosophical stance.

Such findings from science contradict the positivism, objectification, reductionism and determinism of modern science to provide a postpositivist approach to knowledge, where knowledge is an essentially a human construct derived from interactive relationship with the world, which can be described by probability rather than certainty, and whole systems are a focus for understanding how their parts interact. This postpositivist position is important to EfS, as methods of engaging in EfS issues require postpositivist methods. It is also important to understand the significance of positivism in history, in present influences on how people and groups view the world and how institutions may function, as positivism, with its long and dominant history, remains prevalent in its institutional effects and in the minds of many people.

Influences of Ideology

Education has been greatly influenced by ideological influences, and there are two opposing trends:

Instrumental ideologies; 'instrumentalism', 'revisionism' and advocates of 'economic renewal through education' emphasise the need to fit learners into society and to create a skilled workforce which will improve the national economy (DES, 1985). The intention is to improve the efficiency of existing organisations and structures (Oliver, 1982). The 'objectives' model of curriculum planning (Hirst, 1974) applies to these ideologies. Thus, the structure and nature of knowledge is defined, the learning outcomes identified and strategies for achieving these outcomes devised as teaching plans. Instrumental ideology also supports 'knowledge centred ideology' as representing culture to be transmitted through instruction rather than experiential learning (Lawton, 1973). The methods of teaching emphasise instruction and the teacher as the director of the learning process in which the learner is the recipient of knowledge. Instrumental ideology founded on economic rationalism, prioritising education to support economic growth has been dominant in education systems and drives curricula, planning and teaching. Such ideology works directly against EfS.

'Reconstructionist' ideology, however, emphasises education as a process of social change. Thus, education is planned for what society ought to be rather than what it is (Scrimshaw, 1983). Teachers become activators of social change through fostering a critical, analytical and active approach to learning and the curriculum is founded on principles of egalitarianism and democracy. The 'process' model of curriculum planning (Blenkin and Kelly, 1987) applies to this ideology, in which teachers are facilitators of the learning process. Thus, the learner is actively involved in the construction of meaning through interaction with the curriculum. It is evident that a 'reconstructionist' ideology of education is also associated with a learner centred ideology where the curriculum is seen 'in terms of activity and experience, rather than knowledge to be acquired and facts to be stored' (Board of Education [Hadow Report], 1931, p. 75). The process of learning is of prime significance and empiricism, subjectivity, the development of personal meaning, practical activity and problem solving are the modes of learning. Reconstructionist ideology is appropriate to EfS, in which processes of learning are emphasised, with actions linked to informed understanding of implications of choices based on positive values about

human and environmental relationships.

Instrumental ideologies have had most significant influence on education in recent years. For example, free market economics ideology (where deregulation, privatisation of state owned industries, low direct taxation and reduction of the Welfare State are emphasised - sometimes characterised as 'Thatcherism' or 'Reaganomics' after the then British and American prime ministers), has a prevalent influence in development of British curricula in the 1980s, which has also influenced how many other curricula are presently structured. Groups have unequal chances of being heard and acted on (Harnett and Naish, 1990) and the increased powers of the Secretary for State enshrined in the Education Reform Act (ERA, 1988) in Britain ensured that power was effectively governmentally centralised. The so-called 'New Right' of the 1980s was very influential in the educational reforms.

Two main strands in 'New Right' political thinking have been identified and have had particular influences on education:

1. *Neo-conservative thinking* emphasises tradition, authority and national identity /security (Quicke, 1988). Teacher autonomy in curriculum planning and 'localised' concerns (Golby, 1988) were replaced by the need to address the heavy and complex demands of a rapidly implemented statutory National Curriculum, which is founded on a subject based, knowledge centred and objectives model of curriculum planning (Hirst, 1974). As a feature of governmental control, the objectives curriculum model supplanted the previous emphasis on learner centred, process focussed and integrated curriculum approach, which prioritised the developmental needs of children in the so-called 'progressive' curriculum (Blenkin and Kelly, 1987).

2. *Neo-liberal thinking* emphasises free market economics and the extension of its principles into areas of social activity, including education (Demaine, 1988; Gamble, 1983; Levitas, 1986). Quasi competition between schools was introduced through Local Management of Schools with schools having direct control of budgets rather than Local Education Authorities. Also an assessment system linked to 'league tables' of schools' performance was central in this thinking, as it is through such data that parents are supposed to exercise their choice (Taylor and Tytler, 1993). The effect of the policy was to restrict choice further to those who are prepared to pay for education and that 'inner city schools become increasingly disadvantaged' (Whitty, 1989, p. 339).

Neo-conservative and neo-liberal influences work against the aims of EfS. A subject-based curriculum associated with neo-conservative thinking makes it difficult to develop meaningful connections to real life issues, which are complex and interdisciplinary. Also, ideas about free market economics in neo-liberal thinking are problematic. McKibben (2007) discusses how ideas of free market economics are associated with assumptions about continued economic growth. Focus on growing the total size of a country's economy developed particularly after world war two and has become dominant in global economics. He considers that there has been a misconceived global fixation on economic growth based on an assumption that the Earth's resources are infinite, and this is a root cause of the environmental crisis that we currently face. However three fundamental challenges to the fixation on growth have emerged.

Firstly, growth is creating more inequality than prosperity. Inequality is a moral and sustainability issue with ecological, economic, socio-cultural and political impact. About one fifth of the world's population live in abject poverty while another fifth suffer diseases of affluence, such as being overweight or obese, while a small number of people are mega-wealthy with fortunes greater than most countries (Friedman, 2005). The technical revolution levels the global playing field to a degree, so more countries can compete and consume, as exemplified by the rapid growth of countries like China and India where large numbers of people have been lifted out of poverty to engage in consumption patterns equivalent to developed countries, which exacerbates and intensifies problems of sustainability (Friedman, 2008). In developed countries growth also produces more inequality than prosperity; for example, in USA the

mean wage has not increased and income of lowest 90% has declined steadily since 1979 ($27,060 in 1979 and $25,646 in 2005 respectively), and same general pattern is true for 80 countries. However the top 1% of people captured more of the National gain in income than did the bottom 50%. That is, growth is benefitting only a very small percentage of the population (New Economics Foundation, 2003, p. 36).

Secondly there are natural limits to growth, which was made clear in 1972 in *Limits to Growth* as a forewarning to our emerging crisis (Meadows *et al*., 1972). We have not the energy to sustain ever-increasing growth, nor can we cope with the pollution that is associated with it, or the resources to fuel it. The clear evidence of problems of our relations with the environment is highlighted in UNESCO's priority of EfS in the United Nations Decade of Education for Sustainable Development (DESD, 2005-2014). Clearly, the Earth cannot sustain current and projected levels of human inflicted damage to its systems.

Thirdly, growth is not making us happy. For example, in 1946, the USA was ranked the happiest place to live by its inhabitants in surveys of four countries, which fell to eighth among eleven countries thirty years later, and after forty years it was tenth from twenty three countries, many from the third world. In the meantime, there has been a steady decline in the number of Americans who say they are happy with their marriages, satisfied with their jobs or gain pleasure from where they live (Layard, 2005, p. 10). As the most economically wealthy country in the world, the USA demonstrates that high Gross National Product (GNP) and continued economic growth of a country does not equate with happiness.

Free market economics ideology associated with continued economic growth based on competitive global market forces is also a feature of modern thinking in that it is based on short term views, failing to see interconnections and consequences of actions, with exploitation of people and the environment: that is, it is objectivist, reductionist and positivist in essence. A new model of economics is needed to create sustainability, one that enables people to draw resources from the Earth in a way that does not destroy it. McKibben (2007) refers to Schumaker (1972), who espoused economics that value human happiness and the environment over accumulation of material goods, and termed the concept 'Deep Economy' as an echo of 'Deep Ecology' coined by Naess (1973) as a means to examine critically and improve our relationship with nature. A combination of change in approaches to economy and ecology is needed. An example of this is Bhutan's concept of Gross National Happiness, where value is placed on human happiness over economic growth (Bhutan, 20101). There is clearly a need for EfS to develop critical views about excessive consumption patterns in society, named by James (2007) as 'Affluenza', a collective 'disease' of compulsive consumption. 'Affluenza' drives economic markets and directly creates the damaging environmental effects that we are threatened with at this fragile time in human history.

Implications for Pedagogy

As has been discussed, modern, positivist epistemology with instrumental and economic growth-centred ideology is inappropriate for EfS, and contributes significantly to our present problems with the environment through objectification and disconnection from consequences of actions. Stereotypically, pedagogical implications of these features are teacher-directed, transmission approaches to prescribed knowledge within a fragmented curriculum that is unconnected to real life experiences. In contrast, EfS is supported by a postpositivist philosophy and reconstructionist, learner centred ideologies, in which knowledge is constructed by learners with teachers as facilitators to critically understand the environmental, social, economical and political dimensions of contemporary issues, leading to informed action.

Constructivist methods of teaching match our understanding of neurophysiology and how we construct the world, and are also supportive of EfS. Constructivism views individuals as active constructors of understanding. People create understanding from their experiences and the resulting ideas may or may not be similar to other individuals' ideas. Hence people carry self-constructed concepts, which they use to understand their experience, and this may or may not conflict with commonly accepted views, such as scientific theories. Information which conflicts with these personal constructs may create a change in the construct if it is shown to be meaningful, whilst it may be rejected or unnoticed if it does not make sense.

Constructivist models for teaching have been developed to support teachers in helping students

make meaningful sense of phenomena. For example, Ollerenshaw and Ritchie (1993) developed Driver and Oldham's (1986) recommended models for the creation of science curricula on constructivist lines:

ORIENTATION
Arousing children's interest and curiosity
ELICITATION/STRUCTURING
Helping children to find out and clarify what they think
INTERVENTION/RESTRUCTURING
Encouraging children to test their ideas: to extend, develop or replace them
REVIEW
Helping children to recognise the significance of what they have found out
APPLICATION
Helping children to relate what they have learned to their everyday lives
(Ollerenshaw and Ritchie, 1993, p. 6)

Primary Connections (Australian Academy of Science, 2010) have developed the '5Es' model for constructivist engagement, based on similar principles, which are described in sequence as:

ENGAGE
Engage students and elicit prior knowledge
EXPLORE
To provide hands on shared experiences of the phenomenon
EXPLAIN
Develop scientific explanations for experiences of conceptual understanding
ELABORATE
Extend understanding to a new context or make connections to additional concepts through a student-planned investigation
EVALUATE
Students re-represent their understanding and reflect on their learning journey and teachers collect evidence of achievement and outcomes
(Australian Academy of Science, 2010, Primary Connections, 2005, p viii)

Constructivist pedagogy puts the locus of control with the learner, with the teacher as facilitator of learning. EfS requires critical understanding of issues from a scientific-environmental, socio-cultural, economic-political perspective, which implies reconstructionist approach to knowledge, supported by ethically informed values, leading to action for change. This implies that to be effective, EfS needs to draw on constructivist theory and *actively* engage students in learning about sustainability issues generally using democratic, cooperative or collaborative strategies within the concept of a learning community where all involved learn from each other, as well as from learning resources, with challenges to existing views and attitudes in the process of seeking change for sustainability. It requires a change from a transmission model to a transformatory approach to teaching and learning. The teacher is a facilitator of learning rather than a director, and encourages learners to investigate sustainability issues to understand the multi-dimensional nature of the issues and explore possibilities for change.

Jensen's (2002) model of action-competence shown in Figure 2 is particularly appropriate for EfS. Four dimensions provide focus for investigation and students are encouraged to actively engage across dimensions to identify and act on change strategies based on understanding the causes and symptoms of sustainability issues and identified preferred strategies to achieve preferred futures.

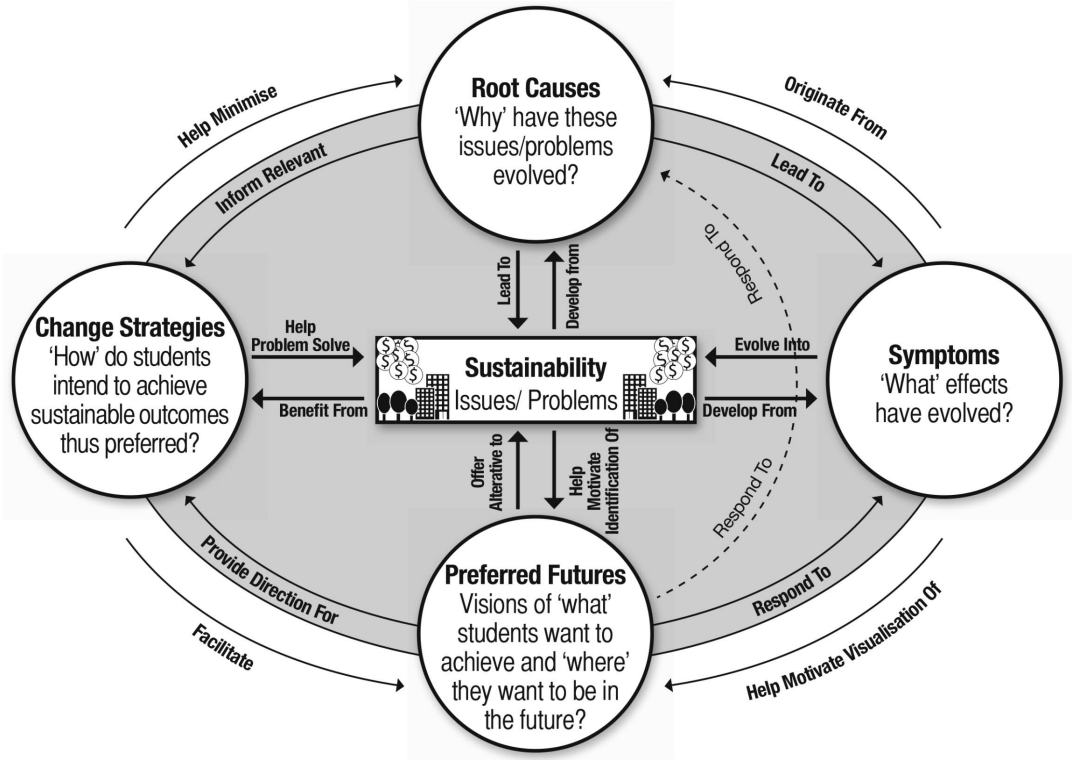

Figure 2: Knowledge required for sustainability (Adapted from Jensen's Action Competence Model: Jensen, 2002, p. 330 by Jenkins, 2009, p. 56).

In approaching EfS, integration between cognitive and affective domains of learning is also needed, as discussed by Littledyke (2008). Multi-strategy teaching including mixed approaches to learning involves what Gardner (1983) termed multiple intelligences. Drama, art and music as particularly supporting the affective domain can be used within the full curriculum range with a variety of resources and stimuli in a range of indoor and outdoor settings to enhance motivation, interest, concern, care, empathy, and enjoyment of learning to drive meaningful learning for informed action.

Features of Suitable Pedagogy to Support EfS

We can identify desirable features of suitable pedagogy for EfS, based on understanding of epistemology, ideology and pedagogy as they impact on our understanding, values and actions concerning sustainability. Features of suitable pedagogy include:

Learner centred emphasis: Learners have priority to direct their investigations and ask meaningful questions, to achieve meaningful understanding of the issues.

Active, constructivist methods: Students' existing views are accommodated, extended or challenged with support from teachers and peers to achieve understanding of commonly accepted views and challenge them if necessary.

Teachers as facilitator of learning: Teachers act as guides supporting student-directed learning, as well as being part of the learning process themselves.

Democratic, shared learning within a learning community: Teachers and students act as co-learners in a shared community of learning. The learning community models what is necessary in the wider social and political community, as shared views need to be achieved to establish what is required for effective action for sustainability.

Multidisciplinary approach: Integrated approaches are required to investigate environmental, social, political and economic dimensions of sustainability issues.

Real contexts for learning: Learning is focussed on real contexts, which exemplify sustainability issues, including contexts that offer possibilities for local action for sustainability.

Critical examination of existing structures and practices: Views, attitudes and common practices are deconstructed, identified and challenged when they are unsustainable as part of the process to find alternatives.

Cognitive and affective integration: Meaningful learning to support informed action is supported by understanding, positive attitudes and active engagement in sustainability investigations.

Metacognition: Learners are supported to be aware of their own learning process and to be critically aware of their role in EfS issues, as well as contradictory influences from society, which can mitigate against EfS.

Exploration of change strategies for sustainability: Consequences of various actions are explored to understand cause and effect of various lifestyles, technologies and social-economic-political structures as a basis for identifying pro-sustainability actions.

Action for sustainability: Action needs to take place at personal and community level. What has been established through sustainability investigations needs to be put into practice in and out of school. Involvement of families and local communities is important to reinforce the process and to extend the impact of sustainable action

School and teachers as models for sustainability: Teachers and schools examine how practices are or are not sustainable and make corresponding changes. Schools become sustainable in their use of energy and resources with sustainable grounds management to encourage biodiversity. Teachers and schools exhibiting sustainable practices will model, inspire and motivate students towards acting sustainability, which is essential for future generations to meet the Brundtland report's exhortation to meet 'the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland Report, cited in United Nations Department of Economic and Social Affairs, 1999, p. 1).

Implications for Science Education Pedagogy to Support EfS

The above principles are applicable across all areas of the curriculum for effective support of EfS, which is essentially interdisciplinary in nature. However science education has a particularly important role in informing the underlying reasons behind the causes, symptoms, preferred futures and strategies to achieve them for sustainability (Jensen, 2002). Littledyke and Taylor, (2009) and Ross *et al*., (2000) provide more detailed examples of approaches to science education for EfS. Table 1 provides examples of how particular science concepts can inform EfS issues and can be explicitly linked to particular forms of action for sustainability. The concepts and associated actions are all interlinked in complex ways, while the principles are important to justify action for sustainability.

Table 1. Examples of science concepts linked to EfS issues and relevant action.

Key concept	Linked science concepts	Links to examples of EfS issues	Links to action for sustainability
Permanence of matter Change of state Chemical change (From a student perspective, materials can be invisible but do not disappear)	Recycling of materials through ecosystems Materials can accumulate in the environment and can pass through food webs Importance of respiration / photosynthesis cycles	Natural recycling and need for recycling of human-processed materials to conserve resources Polluting / toxic chemicals in ecosystems Greenhouse gases linked to fossil fuels and production processes for consumer items	Reduce, recycle, reuse Recycling of packaged materials, composting Support for ecologically sustainable practice - e.g. 'organically' grown produce, use of 'green' chemicals in the home

Key concept	Linked science concepts	Links to examples of EfS issues	Links to action for sustainability
Energy transfer in Natural ecosystems Industrial processes and machines	Energy through food webs / chains Insulation Heat transfer through various materials Science of the greenhouse effect	Sustainable approaches to agriculture, industrial processes, energy use Implications of fossil fuels on greenhouse gases and climate change Sustainable energy sources Energy conservation	Reduced carbon imprint through: Electricity (or gas) use in home – insulation, lights, standby, renewable energy sources, etc. Transport - cycle, shared, fuel efficient transport, etc. Eat balanced, appropriate amount, low on food chain, support organic, local production, reduced packaging
Biodiversity	Complex interactions in ecosystems Interconnectedness through ecology, Evolutionary patterns (history of living things), DNA (genetic code)	Threatened ecosystems and endangered species – extinctions Environmental ethics - animal welfare, environmental action Empathy with other living things – 'the family of life' Awe, wonder and beauty of nature Our place in history and the universe	Impact of resource depletion on ecosystems and habitats – reduced consumption Protect endangered species and ecosystems – environmental responsibility Eating patterns – organic production supports rich ecosystems, impact of eating low on food chain, animal cruelty, low fish stocks

Ideas about conservation of matter are essential to understand the basis of various forms of pollution linked to human activity, particularly the basis of climate change associated with greenhouse gas emissions and how polluting chemicals from industrial processes can have damaging effects on ecosystems and human health. Actions to reduce consumption as purchasers of produced goods, to recycle materials with support of local government authorities or through composting for garden use, and to reuse wherever possible are essential principles for EfS, supported by scientific understanding about materials, their properties and uses in industry and in the home.

Ideas about energy transfer through natural systems and through industrial processes are important to understand principles of fuels fused for powering machines including transport, energy flow through ecosystems to justify sustainable eating patterns and the importance of energy conservation to justify reduced carbon imprint. Associated actions are linked to general levels of consumption (another manifestation of reduce, recycle and reuse), to energy conservation in the home, to use of transport and choices in food, which have ecological as well as health implications (for example, eating a balanced diet, eating low on the food chain – that is, adopting a vegetarian diet or eating less meat – supporting organic, ecologically sustainable practices and local food production to avoid 'food miles' with extensive fuel use for transport and corresponding greenhouse gas emissions).

Biodiversity concepts linked to ecosystems interactions and evolutionary patterns are important to give a basis for environmental ethics. Such ideas show how consumption patterns affect habitats through resource depletion, while understanding ecological, genetical and evolutionary relationships shows that all living things are part of the 'family of life'. Experiences of natural beauty through learning in natural settings, and knowledge of our place in the universe can support awe and wonder at the magnificent diversity of our planet. Such understanding and empathy can support care for living things to justify environmental actions, including sustainable eating and purchasing patterns for health and general protection and care for living things.

In addition, such concepts and attitudes supported through science will also justify issues of equity in how we treat other people with the need for equitable distribution of resources. In these ways, science knowledge links closely to attitudes and action to support EfS and the wider links between the environmental, social, economic and political dimensions can be made clearly to justify and support action that is essential for sustainability.

Table 2. Summary of the epistemological, ideological and pedagogical influences in modern, positivist and postpositivist approaches to science education.

	Modern, positivist approaches to science education	Postpositivist approaches to science education
Epistemological assumptions	Science as objective proof, yielding truth, being value free and with unique methods, implemented primarily through reductionist approaches. Such views are still held by many but have been overturned by findings in science and the philosophy of science.	Science involving human endeavour, informed by values, exploring whole systems and interconnected ideas, producing tentative knowledge subject to challenge and social acceptability. Such views are supported by findings in science and the philosophy of science.
Ideological influences	Instrumental ideology, fitting learners into society, associated with education to support economic growth. Assumptions of continued economic growth are unsustainable and associated with ideas of exploitation of unlimited resources and social inequity.	Reconstructive ideology emphasising social change through critical approach to understanding EfS issues and possible solutions. Problems and possible actions to solve EfS issues need to be investigated and supported by positive attitudes to promote suitable action for change.
Associated pedagogy	Knowledge centred pedagogy within a subject based curriculum, disconnected with real world application and with focus on individual learning. Objectives led, with cognitive emphasis, and summative, hierarchical assessment prioritised to inform selection for employment. Teachers as directors, with transmission approach and learners as recipients of knowledge. Such pedagogy acts as significant barrier to EfS and is often driven by prescribed curricular and assessment pressures plus limited perspectives of teachers and schools.	Learner centred pedagogy in a shared learning community, with multi disciplinary approach, active learning, metacognitive reflection, and meaningful understanding of real world application of ideas. Process led with cognitive / affective integration, with critical, analytical approach to learning and investigation of change strategies to identify and promote action for sustainability. Teachers as facilitators, with constructivist approach to scaffold and support learners' investigations. Schools and teachers as models for sustainability. Such pedagogy acts as a driver to support effective EfS.

Conclusions

This paper has discussed how ideological, epistemological and pedagogical assumptions of curriculum planners and those who implement curricula affect EfS. Table 2 summarises the discussion and illustrates how modern, positivist or postpositivist approaches to science education can provide barriers or drivers to EfS. As unsustainability is not tenable option for society, postpositivist pedagogical approaches that support sustainability must be seen as an imperative rather than an option. Some of these pedagogical approaches are being put into practice; for example the development of resources to support teaching for sustainability, the establishing of eco-schools as models for sustainability practice and some very good guidance for development of EfS at national, regional and local level (see introduction). However, understanding of the barriers and drivers to EfS is also needed to counter the barriers and to foster a more systematic integration of EfS within the curriculum to achieve effective action for sustainability.

References

Ackerman, F. and Stanton, E. (2006). Climate Change – The Costs of Inaction. Available at: http://www.foe.co.uk/resource/reports/econ_costs_cc.pdf (Accessed July 8, 2009).

Atkins, P. (2003). *Galileo's Finger: the Ten Great Ideas of Science*. Oxford: Oxford University Press.

ACARA (Australian Curriculum Assessment and Reporting Authority) (2010). *Australian Curriculum*. Available at: http://www.australiancurriculum.edu.au/Home (Accessed July 3, 2010).

Australian Government Department of Environment, Water, Heritage and the Arts (2009). *Living Sustainably: the Australian Government's Action Plan for Education for Sustainability*. Available at: http://www.environment.gov.au/education/publications/pubs/national-action-plan.pdf (Accessed July 3, 2010).

AuSSI (2009) *Australian Sustainable Schools Initiative*. Available at: http://www.environment.gov.au/education/aussi/index.html (Accessed July 3, 2010).

Australian Academy of Science (2010). *Primary Connections: Linking Science with Literacy,* 2005. Available at: http://www.science.org.au/primaryconnections/ (Accessed July 23, 2010).

Blenkin, G.M. and Kelly, A.V. (1987). *The Primary Curriculum: A Process Approach to Curriculum Planning.* 2nd. Ed., London: PCP.

Board of Education (1931). *Report of the Consultative Committee on the Primary School.* The Hadow Report, London: HMSO.

Bowles, S. and Gintis, H. (1976). *Schooling in Capitalist America.* London: Routledge, Keegan and Paul.

Bhutan (2010). Gross National Happiness. Available at: http://www.grossnationalhappiness.com/ (Accessed July 6, 2010).

Demaine, J. (1988). Teachers' Work, Curriculum and the New Right. *British Journal of Sociology of Education,* 9, 247-264.

DES (Department of Education and Science) (1985). *Better Schools.* London: HMSO.

Doidge, N. (2007). *The Brain that Changes Itself.* New York: Viking, Penguin.

Driver, R. and Oldham, V. (1986). A Constructivist Approach to Curriculum Development in Science. *Studies in Science Education,* 13, 105-122.

Eagan, D.J. and Orr, D.W. (Eds.) (1992). *The Campus and Environmental Responsibility,* San Francisco: Jossey-Bass.

Education Reform Act (1988). London: HMSO.

EPA (Environmental Protect Authority) Victoria (2010). *Ecological Footprint: Measuring our Impact on the Environment*. Available at: http://www.epa.vic.gov.au/ecologicalfootprint/ausFootprint (Accessed July 4, 2010).

Ehrlich, P.R. and Ehrlich, A.H. (2008). *The Dominant Animal: Human Evolution and the Environment.* London: Island Press / Shearwater Books.

Fox, W. (1990). *Toward a Transpersonal Ecology,* Massachusetts: Shambala.

Friedman, T. (2005). *The World is Flat*. Victoria: Allen Lane

Friedman, T. (2008). *Hot, Flat and Crowded*. Victoria: Allen Lane.

Foucault, M. (1977). *Discipline and Punish: The Birth of Prison.* Harmondsworth: Penguin.

Gamble, A. (1983). Thatcherism and Conservative politics. In: Hall, S. and Jacques, M. (Eds.) *The Politics of Thatcherism.* London: Lawrence and Wishart.

Gardner, H. (1993). *Multiple Intelligences: The Theory in Practice.* New York: Basic Books.

Golby, M. (1988). Traditions in Primary Education. In: Clarkson, M. (Ed.), *Emerging Issues in Primary Education.* Lewes: Falmer.

Harlen, W. (1992). *The Teaching of Science.* London: David Fulton.

Hartnett, A. and Naish, M. (1990). The Sleep of Reason Breeds Monsters: The Birth of a Statutory Curriculum in England and Wales. *Journal of Curriculum Studies,* 22, 1-16.

Harvey, D. (1989). *The Condition of Postmodernity.* Oxford: Blackwell.

Hirst, P. (1974). *Knowledge and the Curriculum: A Collection of Philosophical Papers.* London: Routledge, Keegan and Paul.

Human Development Report (2007/08), UNDP. Available at: http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf (Accessed July 11, 2009).

James, O. (2007). *Affluenza.* Sydney: Random House.

Jenkins, K. (2009). Linking Theory to Practice: Education for sustainability and learning and teaching, in Littledyke, M. Taylor, N. and Eames, C. (Eds.) *Education for Sustainability in the Primary Curriculum: a guide for teachers.* South Yarra: Palgrave Macmillan.

Jensen, B. (2002). Knowledge, Action and Pro-environmental Behaviour. *Environmental Education Research*, 8(3), 325-334.

Kaufmann, S. (1992). *The Origins of Order.* Oxford: Oxford University Press.

Kollmuss, A. and Agyeman, J. (2002). Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-environmental Behaviour? *Environmental Education Research,* Vol. 8, No. 3, 239-260.

Kuckartz, U. (2009). Cherries from Timbuktu. Why Despite Better Knowledge, Behaviour Patterns Do not Change. Presentation to *The Great Transformation. Climate Change as Cultural Change International Conference,* June 8-10, Essen, Germany. Available at: http://www.greattransformation.eu/images/stories/downloads/kuckartz_presentation_opt.pdf (Accessed July 8, 2009).

Kuhn, T. (1970). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Lang, J. (2005). *Education for Sustainability*, *EQ Australia*. Melbourne VIC: Curriculum Corporation, Available at: http://www1.curriculum.edu.au/eq/2005summer/article2.php (Accessed July 5, 2010).

Lawton, D. (1973). *Social Change, Educational Theory and Curriculum Planning*. London: University of London Press.

Layard, R. (2005). *Happiness: Lessons from a New Science*. New York: Penguin Press.

Levitas, R. (ed.) (1986). *The Ideology of the New Right.* Oxford: Polity Press.

Lewin, R. (1993). *Complexity: Life on the edge of chaos.* London: Phoenix.

Littledyke, M. (2008). Science and Environmental Education: Approaches to Integrating Cognitive and Affective Domains. *Environmental Education Research,* Vol. 14, No. 1, 1-17.

Littledyke, M. and Taylor, N. (2009). Education for Sustainability in Primary Science. In: Littledyke, M. Taylor, N. and Eames, C. (Eds.) *Education for Sustainability in the Primary Curriculum: A guide for Teachers.* South Yarra: Palgrave Macmillan.

Littledyke, M., Taylor, N. and Eames, C. (Eds.) (2009). *Education for Sustainability in the Primary Curriculum: a guide for teachers.* South Yarra: Palgrave Macmillan.

Milgram, S. (1974). *Obedience to Authority*. London: Tavistock.

McKibben, B. (2007). *Deep Economy: Economics as if the World Matters*. Oxford: Oneworld Publications.

Meadows, D.H., Meadows, D.L., Randers J. and Bahrens W.W. (1972). *Limits to Growth*. Universe Books: NY.

Medawar, P. (1979). Is the Scientific Paper a Fraud? London: BBC Publications. Reprinted in Brown, J., Cooper, A. Horton, T. Toates, F. and Zeldin, D. (Eds.), *Science in Schools,* Milton Keynes: Open University Press.

Merchant, C. (1980). *The Death of Nature: Women, Ecology and the Scientific Revolution.* New York: Harper and Row.

Monod, J. (1972). *Chance and Necessity.* London: Collins.

Morrison, K. and Ridley, K. (1988). *Curriculum Planning and the Primary School.* London: Paul Chapman.

Naess, A. (1973). The shallow and the deep long-range ecology movements. *Inquiry,* 16, pp. 95-100.

National Curriculum Council (1990). *Curriculum Guidance 7: Environmental Education*. York: NCC.

New Economics Foundation (2003). *Real World Economic Outlook*. London: New Economics Foundation

New South Wales Government (2010). *Learning for Sustainability: NSW Environmental Education Plan 2007-2010*. Available at: http://www.environment.nsw.gov.au/resources/cee/2006347_lfsenvedplan20072010.pdf (Accessed July 5, 2010).

Ollerenshaw, C. and Ritchie, R. (1993). *Primary Science: Making it Work.* London: David Fulton.

Oliver, D. (1982). The primary curriculum: a proper basis for planning. In: Richards, C. (Ed.), *New Directions in Primary Education.* Lewes: Falmer.

Orr, D.W. (1992). *Ecological Literacy: Education and the Transition to a Postmodern World.* Albany, NY: State University of New York Press.

Popper, K. (1963). *Conjectures and Refutations.* London: Routledge, Keegan and Paul.

Prigogine, I. and Stengers, I. (1984). *Order Out of Chaos: Man's new dialogue with nature.* New York: Bantam Books.

Quicke, J. (1988). The 'New Right' and education. *British Journal of Educational Studies,* 26, 5-20.

Ross, K., Burch, G., Lakin, L. and Littledyke, M. (2001). *Science Issues and the National Curriculum.* CD ROM. Cheltenham: University of Gloucestershire.

Schumaker, (1972). *Small is Beautiful: Economics as if People Mattered*. London: Harper.

Scrimshaw, P. (1983). Educational Ideologies, Unit 2, E204, *Purpose and Planning in the Curriculum*. Milton Keynes: Open University Press.

Swimme, B. (1988). The Cosmic Creation Story. In: Griffen D.R. (Ed.), *The Reenchantment of Science: Postmodern Proposals*. Albany: State University of New York Press.

Taylor, T. and Tytler, T. (1993). *A Lesson for us All: The Making of the National Curriculum.* London: Routledge.

UNESCO (2004). *Highlights on Progress to Date – Education for Sustainable Development United Nations Decade 2005-2014*. UNESCO. Available at: http://www.environment.gov.au/education/publications/pubs/undesd-progress.pdf (Accessed January 5, 2008).

UNESCO (2010). Education for Sustainable Development. Available at: http://www.unesco.org/en/esd/ (Accessed July 5, 2010).

United Nations Department of Economic and Social Affairs (UN DESA) (1999). A/Res/42/187 *Report of the World Commission on Environment and Developmen*. Available at: http://www.un.org/documents/ga/res/42/ares42-187.htm Accessed February 12, 2009.

Union of Concerned Scientists (1992). *World Scientists' Warning to Humanity.* Union of Concerned Scientists: Cambridge, MA.

Whitty, G. (1989). The New Right and the National Curriculum: State Control or Market Forces? *Journal of Educational Policy,* 4, 329-341.

Yencken, D. and Henry, N. (2008). Common Misconceptions about Climate Change. Available at: http://www.australiancollaboration.com.au/_factsheets/1.%20Misconcept_Climate_FactSheet.pdf (Accessed December 15, 2008).

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