Blurring the Boundaries – STEM Education and Education for Sustainable Development

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Abstract
Both the concept of sustainable development and the nature of education for sustainable development (ESD) are highly contested. ESD can be construed as a part of sustainable development policy as governments attempt to bridge the 'value-action gap' between what we know we should be doing (e.g. to combat climate change) and what we actually do. Alternatively sustainability can be construed as a 'frame of mind'; within this paradigm ESD is seen as a way of bringing to the surface underlying values and beliefs through the exploration of contradictions and arguments.

STEM (Science, Technology, Engineering and Mathematics) education is equally contested. At one end it is seen as a pre-vocational learning or even training to encourage students to pursue science and maths in particular en route to professional work in engineering and technology. 'Successful' STEM is then measured in take-up of certain subjects Post-16 or at tertiary level, or in terms of attitudes towards engineering and technology. Conversely, STEM can be seen as an entitlement to learn in a different way, in which the boundaries between the component subjects of STEM become blurred and learners are encouraged to develop transferable skills *and* knowledge and the metacognitive skills that enable this transfer to be used creatively.

In this paper the author examines how teachers can plan for a creative interaction between ESD within the 'frame of mind' approach, and STEM education as a metacognitive entitlement. It argues that current curriculum reforms in England[1] offer unprecedented opportunities for design and technology teachers to extend student engagement and learning beyond the prescribed Design and Technology (D&T) curriculum thereby enhancing creativity and critical reflection. Using sustainability contexts for STEM activities might provoke critical discourse within schools and their wider communities, thereby creating new opportunities for ESD.

Key words
Education for Sustainable Development (ESD), STEM, Curriculum development, values in design and technology

Introduction
This paper is based on the premise that using the context of sustainability within STEM projects will enable teachers to plan creative interactions and engage in critical discourse within schools. Focusing on the secondary curriculum in England, the paper discusses the theoretical framework for sustainable development, education for sustainable development (ESD), initiatives for ESD and the development of STEM which is both problematic and contested. It then introduces other recent curriculum initiatives such as the concept of personal, learning and thinking skills (PLTS), the extended schools agenda, the new National Curriculum for pupils aged 11-14 and diplomas for pupils aged 14-19 years, which it argues can provide a framework for both the ESD and PLTS agendas. It concludes that 'fitting the jigsaw together' will help break down barriers and introduce into the curriculum a willingness to encourage controversy and debate.

The 21st Century educational context
Many of the certainties of the 20th Century are no more. Today's teachers and educational policy makers grew up in a culture characterised by assumptions of unlimited growth, the long-term availability of natural resources (especially of fossil fuels) and a naïve assumption that the planet has a carrying capacity that more or less allowed humanity to develop in whatever way it saw fit. These assumptions are now widely challenged – (see for example Simmons, 2000 and World Wide Fund for Nature (WWF), (2008). WWF report that humanity's ecological footprint only exceeded the planet's biocapacity as recently as 1986, since when we have been living beyond our means with an inexorable upward trend. Pointing out how demands on the planet's resources now exceed the planet's regenerative capacity by more than 30% they warn that the 'global overshoot' is growing. The result of this is that ecosystems are being run down and that waste is accumulating in the air, on land and in water. We are faced with deforestation, decreasing biodiversity and climate change that are putting the well-being and development of all nations at increasing risk (WWF, 2008:2).

[1] *In this article the focus is on policy in England; there are similar policies in Scotland, Wales and Northern Ireland.*

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The Intergovernmental Panel on Climate Change (IPCC) now says *'with very high confidence* that the net effect of human activities since 1750 has been one of warming' (IPCC, 2007:6). This report continues:

> *Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. (ibid: 6)*

At the same time advances in the STEM domains of science, technology, engineering and mathematics have given us both the capacity for causing such degradation, the tools for identifying it and understanding its causes, and hopefully for informing genuinely intelligent design decisions in the future. This increased understanding of the anthropogenic causes of climate change, the limitations of peak oil and more recently the global economic crisis all challenge the 'common-sense' wisdom that we can safely do what we want. The search is now on for development – or change – that is truly sustainable.

Sustainable development

The terms 'sustainable development' and 'sustainability' are now on everyone's lips. However, the concept of sustainable development is problematic and contested. Many people rely on the Bruntland definition as "… development that meets the needs of the present without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development (WCED), 1987). This affords a simple handle for discussing sustainable development, even if the nature of 'development' is not made clear, and there is no consensus as to what 'needs' really are!

Bonnett (2003) points out how sustainable development has become both the dominant and politically attractive idea when addressing environmental issues. But he points out that the very term 'sustainable development' has a certain seductiveness about it. It promises to reconcile the wish to preserve and conserve nature, *and* the urge to accommodate human aspirations to 'develop' in the sense of having more or better. Bonnet asks if this marriage is possible, or whether it involves a 'semantic sleight of hand that veils an undergrowth of ambiguities and tensions which are in danger of vitiating the notion and consequently any environmental policy based on it' (Bonnett, 2003: 676).

Often sustainable development is thought about as having economic, environmental and social dimensions; if any development or change is to be sustainable it has to meet social and economic criteria concerning the needs of future generations, and not just be informed by narrow environmental considerations. This can be represented as three interlocking circles – see the left hand side of Figure 1 below. However, this image might suggest that development in any one dimension can occur without impacting on the others. Webster (2004) criticises this view suggesting that it leads to fragmented thinking. The planet, he points out, is a finite ecosystem. Elshof (2005) writing about teachers' perceptions of sustainable development, notes that sustainability has to deal with the mismatch between "our technosphere and the capabilities of the biosphere to regenerate and sustain the life support systems upon which we all depend"(p.174).

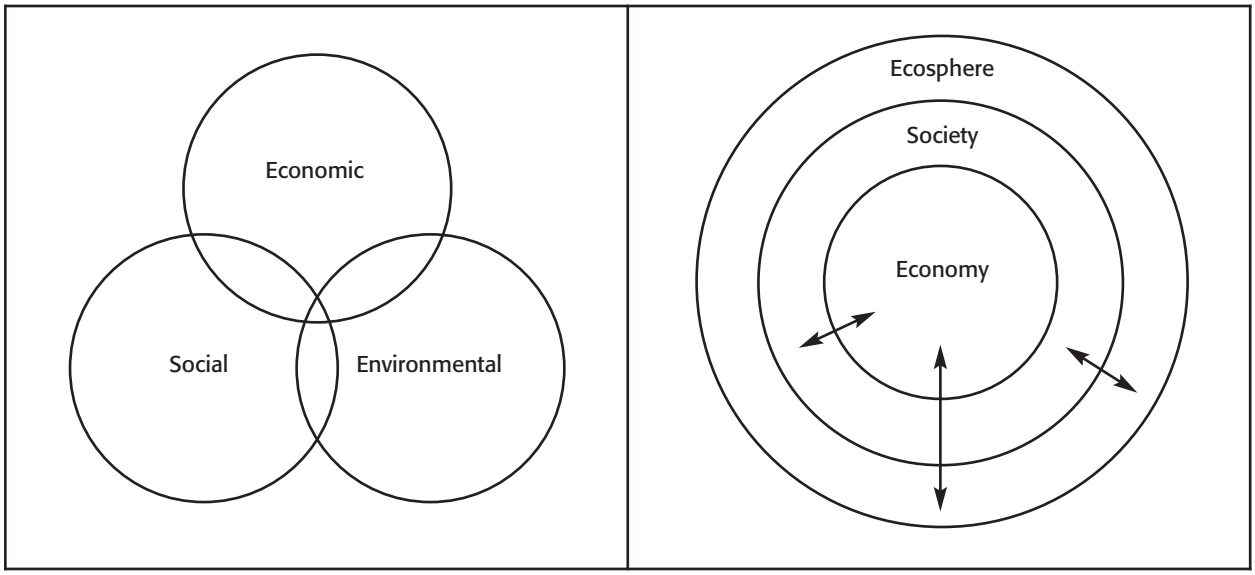

Figure 1. How economic, social and environmental dimensions of sustainable development interrelate (adapted from Webster, 2004:40)

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Webster (2004) proposes an alternative image, the three concentric circles on the right hand side in Figure 1. Here the economy is in the centre, serving the needs of society which is represented by the middle circle – Webster sees the economy as 'a means of servicing human needs rather than people and resources servicing the economy' (Webster, 2004: 41). Both economy and society have to operate within the finite constraints of the ecosphere. Webster talks of a society in which development needs to focus on improving the quality of life, seeking change in which fairness and better human relationships are more important than seeking more and more or ever increasing consumption (Webster, 2004: 40). It will be argued below that this latter conceptualisation of the relationship between these three dimensions of sustainable development is critical if STEM education is to make a positive contribution to addressing the problems of the 21st century.

Among the many ways that sustainable development is conceptualised it is worth noting the approach of the UK government. It identifies four key areas of activity (DirectGov, 2008):

- sustainable consumption and production: changing the way products and services are designed, produced, used and disposed of – in short, achieving more with less;
- climate change and energy – reducing greenhouse gas emissions in the UK and worldwide whilst at the same time preparing for the climate change that cannot be avoided;
- natural resources – understanding the limits of the natural resources that sustain life, such as water, air and soil;
- sustainable communities – looking after the places people live and work, for example, by developing green, open spaces and building energy-efficient homes.

Again, it could be argued that these are natural contexts for action in any or all of the STEM subjects of science, technology, engineering and mathematics.

Education for Sustainable Development (ESD)

As the concept of sustainable development has changed, so has the concept of education for sustainable development or ESD. Huckle (2006) undertook an extensive review for the Teacher Training Agency or TTA (now called the Teacher Development Agency, TDA) of ESD theory and practice both in England and internationally. In it he analyses how the construction of ESD has changed, focusing *inter alia* on the views of UNESCO. By the time of the Earth Summit of 2002 ESD had gone far beyond its roots in environmental education and was seen as catalyst for change and a way into challenging attitudes and behaviours. It is concerned with real contexts and real decisions relating to the environment, economy and community well-being, and to the connections between these, for present and for future generations.

Bonnet (2008) distinguishes between two poles of ESD – teaching to promote sustainable policy, and sustainability as a 'frame of mind'. The policy or value-action gap approach is to spread knowledge among learners about key issues relating to sustainable development (e.g. peak oil, the carbon cycle, global warming, preventing waste). As learners and their communities better understand the causes and consequences of unsustainable development, this will lead to changes in behaviour. It is not apparent that this works. At the other end of the continuum, Bonnet sees sustainability and education for sustainability as a 'frame of mind'. This is more akin to a perspective on the world and the place of humans in it where the guiding question is "What constitutes a right relationship with nature?" This is not something to be taught (that would be an example of the paradigm of ESD as policy) so much as an arena for discussion and debate.

Bonnet's alternative characterisations of sustainable development as policy versus a frame of mind are mirrored by other authorities. Vare and Scott (2007) review and earlier study by Scott and Gough (2003) in which the authors identified three approaches to sustainable development, learning and change. These are described as follows:

> Type 1 approaches assume that the problems humanity faces are essentially environmental, and can be understood through science and resolved by appropriate environmental and/or social actions and technologies. It is assumed that learning leads to change once facts have been established and communicated.
>
> Type 2 approaches assume that our fundamental problems are social and/or political, and that these problems produce environmental symptoms. Such fundamental problems can be understood by means of anything from social-scientific analysis to an appeal to indigenous knowledge. The solution in each case is to bring about social change, *where learning is a tool to facilitate choice between alternative futures which can be specified on the basis of what is known in the present.*
>
> In both Type 1 and Type 2 approaches, learners, broadly speaking, learn to value what others tell them is important. Both these approaches have a long history and are attractive to pressure groups who advocate a shift to sustainability.

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> Type 3 approaches assume that what is (and can be) known in the present is not adequate; desired 'end-states' cannot be specified. This means that any learning must be open-ended. Type 3 approaches are essential if the uncertainties and complexities inherent in how we live now are to lead to reflective social learning about how we might live in the future.

Vare and Scott (2007) build on this to distinguish between what they call ESD1 and ESD2. ESD1 is based on Types 1 and 2 above and described as 'the promotion of informed, skilled behaviours and ways of thinking, useful in the short term where the need is clearly identified and agreed'. It is learning *for* sustainable development. ESD 2 is based on Type 3 and is 'building capacity to think critically about what experts say and to test ideas, exploring the dilemmas and contradictions inherent in sustainable living' (Vare and Scott 2007: 191). It is learning *as* sustainable development. Unlike Bonnet and Huckle who see these two approaches as mutually incompatible, Vare and Scott argue that both are needed; they are essentially interrelated and complementary – the yin and yang of ESD.

Over twenty years ago Stevenson (1987) reviewed the state of environmental education (the precursor of ESD). He identified contradictions arising from what he saw to be the main culture of schools – institutions devoted to the transmission of culture and information – and concluded that this does not sit comfortably with a critical, problem-solving approach in which learners engage in ideological and critical enquiry. He argued that the gap between the rhetoric of environmental education and the reality in schools is to be expected given the traditional purpose and structure of schooling. He revisited that same issue twenty years later and concluded that things had got worse. In essence he argues that schools are concerned mainly with controlling young people, what they think about and the ways that they think, whereas ESD needs to provide the opportunity for learners and teachers to be critical and active. However, Stevenson (2007) also sees the emergence of new spaces and opportunities in which teachers can move away from implementing environmental education towards creating 'teacher discourse communities' that are grounded in the particular (as opposed to a national curriculum that has to be delivered) and in action, spaces which are characterised by sharing, questioning, challenging and problem-solving.

Initiatives on Education for Sustainable Development

In whatever way sustainable development and ESD are conceptualised, the exigencies of unsustainable development have had and continue to have an impact on education policy, nationally and internationally. This led the United Nations to declare a Decade of Education for Sustainable Development with the following purpose (UNESCO, 2008):

> *The goal of the United Nations Decade of Education for Sustainable Development (2005-2014, DESD), for which UNESCO is the lead agency, is to integrate the principles, values, and practices of sustainable development into all aspects of education and learning. This educational effort will encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.*

This international initiative is mirrored in England by the Department for Children, Schools and Families (DCSF) which has an ambitious sustainable development action plan for educational institutions at all levels (DCSF, 2008a). This builds on a UK government framework for sustainable development that is based on five principles.

1. living within environmental limits
2. ensuring a strong, healthy and just society
3. achieving a sustainable economy
4. using sound science responsibly
5. promoting good governance.

The document states that a policy must respect all five principles before it can be considered sustainable (DCSF, 2008a: 4) (see appendix).

DCSF educational policy is elaborated for the different sectors. For schools there is a portal on sustainable schools (DCSF, 2008b). This proposes a National Framework (DCSF, 2008c) for all schools to assess how they can become more sustainable in how they operate (the campus strand), in their relations with the local community (the community strand) and in teaching and learning (the curriculum strand). The DCSF suggests that these strands can be approached through any single or combination of eight 'doorways'. The first five have more of an environmental focus. They are: food and drink, energy and water, travel and traffic, purchasing and waste, buildings and grounds. It is worth noting that these first five doorways are all potential contexts for STEM activity. The remaining three are more concerned with the way that issues are addressed; these doorways are inclusion and participation, local well-being, and the global dimension. However it is made clear that the doorways are interconnected and policy or activity via any one doorway, or in any of the three strands of campus, community and curriculum, will inevitably connect with policy and action in

one of the others. Equally no doorway is exclusively environmental; decisions on purchase of food, for example, have economic and social implications, both locally and globally. The National Framework focuses on ways in which sustainable development can be embedded into whole-school management practices as well as providing practical guidance to help schools operate in a more sustainable way.

Is this a promising space in which teachers can co-construct a professional discourse of the sort advocated by Stevenson, one that will lead to change? Or is it just another top-down curriculum for teachers to deliver? Winter (2007) argues that ESD policy in England will do little to address global problems and actually serves to block enquiry and restrict the scope of possible solutions. She does, however, call for a search for spaces in teacher education and across the school curricula in which there can be a critical and deconstructive questioning of sustainable development and ESD. Huckle (2008) is equally scathing about New Labour's policies on sustainable development and ESD. He describes the action around the eight doorways as a means of ecological modernisation of the school and its community. But there is, according to Huckle, little evidence that this will reveal and challenge the interests and policies that make it difficult for schools to be truly sustainable in the first place.

From examining official documents and summarising the conclusions of the authors above, one can conclude that there are broadly two basic approaches to ESD: teaching *about* the key issues and encouraging different behaviours, and encouraging critical reflection linked to action. It will be argued below that new opportunities afforded by the emerging STEM agenda and the attention being given to personal learning and thinking skills (PLTS) together provide an exciting opportunity to advance ESD in an effective way.

The problematic nature of STEM

The acronym 'STEM' stands for science, technology, engineering and maths. But STEM as an educational concept is problematic. There is little consensus as to what it is, how it can be taught in schools, whether it needs to be taught as a discrete subject or whether it should be an approach to teaching the component subjects, what progression in STEM education is, and how STEM learning can be assessed. Some people define any activity that involves any of science, technology, engineering or mathematics as a STEM activity; others argue that intrinsic to the concept is some linking of two or more of the component areas of learning, and that real STEM must be more than the sum of its parts.

The roots of STEM lie in concern about skills shortages in the UK. In July 2004 HM Treasury, the DTI and DfES produced the seminal 'Science and Innovation investment framework 2004-2014' (Brown et al, 2004). It starts with the words:

> *The nations that can thrive in a highly competitive global economy will be those that can compete on high technology and intellectual strength – attracting the highest-skilled people and the companies which have the potential to innovate and turn innovation into commercial opportunity. These are the sources of the new prosperity* (p.4).

Achieving this demands a strong supply of scientists, engineers and technologists. The report called for a step change in the quality of teachers, better science results at Key Stage 4 for pupils aged 14 -16 years and a greater take-up of science, engineering and technology subjects Post-16. This call for action was reinforced two years later in the STEM report (Rammell et al., 2006). Here the government maintained its emphasis on strengthening the country's science base, and proposed a system of STEM delivery for every school, college, learning provider and learner. They recommended a high-level STEM strategy group and a National STEM Director to drive these initiatives forward (op cit:3). The Leitch Report gave further impetus to this at the end of 2006, arguing that Britain was on a road to mediocrity unless there was a massive and co-ordinated effort to meet skills shortages (Leitch, 2006).

Initially the focus was on science, engineering and technology – it was called SET. But by 2006 SET had become became STEM as the centrality of maths in science, engineering and most of technology education was recognised. It was further observed by 2006 that there had been burgeoning of uncoordinated STEM experiments and large amounts of money had been spent. The STEM report contained a raft of proposals to bring order to this chaos, proposing no less than 17 lines of action. This in turn led to the STEM programme and in particular to the STEM Framework (National Science Learning Centre, 2008a). In it there are 11 Action Programmes covering everything from teacher recruitment and in-service training (also known as Continuing Professional Development or CPD) to enriching the curriculum in the STEM subjects, careers guidance and developing national, regional and local infrastructures to build capacity. A parallel publication to this important policy document was sent to all schools in 2008 (National Science Learning Centre, 2008b). This urges schools to grasp opportunities such as:

Building a stimulating curriculum where the links across all STEM subjects are explicit to teachers and learners alike

- drawing on outside organisations to engage learners – by using 'real world' cross-curricular STEM contexts and challenges;
- working together with scientists, technologists, engineers and mathematicians from the world of work to give learners an exciting yet realistic picture of a future which motivates them to choose these subjects;
- highlighting the wide range of rewarding careers available to those who choose STEM subjects in school or college.

(National Science Learning Centre 2008b:3)

The payoff for schools is described in terms of increased motivation and rising standards, an enhanced profile in the community and one which will help teacher recruitment and retention; it goes beyond just policy to address skills shortages.

As a wider group of educators joined those whose prime concern is skills shortages to debate the STEM agenda, a new question has emerged. What are the educational objectives of STEM beyond meeting a skills shortage? This is a problematic area. The DCSF for example promotes STEM as a means of addressing skills shortages. Launching a three year STEM campaign in early 2008 they explained that it "will target students of secondary school age, their parents, and the teaching workforce and is based on the proposition that studying STEM creates a pathway to a brighter future, opening up a wide range of interesting and exciting career opportunities" (Central Office of Information, 2008). The website that underpins this campaign is called Science and Maths.net – see where they can take you and on the front page a wide variety of technology and engineering-based jobs are showcased (DCSF 2008d). In contrast to the presumption that STEM education for all justified by a national skills shortage, one might even ask whether it is morally justified to expose all learners to STEM if only a few of them are going on to STEM-based careers. Millar et al (2006) argue that this is unacceptable social engineering on a grand scale. There is an alternative rationale for STEM learning – that is has an intrinsic educational value and therefore is deserving of a place in general education. An analogy is with physical education (PE) – most people would agree that PE is valuable in itself even though a tiny minority of students go on to become professional athletes or work in the sports-related industries.

The STEM team at the Specialist Schools and Academies Trust (known as SSAT) has developed a list of desirable learning outcomes of STEM education (SSAT, 2008). These include student outcomes such as having engaged in open-ended problem solving activities, leading to greater confidence in real-life problem solving, and improved team work and communication skills. In the longer term, students will have further developed higher order thinking skills, enabling *transfer* of learning between subject areas. This might be unconscious (a seamless switching between what they have learnt in different subject areas), or deliberate with the metacognitive super-skill of choosing which mode to think in – as designer, engineer, scientist or mathematician.

As well as the purpose of STEM being contested (skills shortages versus a broad educational entitlement), there is also debate about the scope of STEM. Some people argue that any activity in one or more of the disciplines of science, technology, engineering or mathematics can be counted as a STEM activity. As mentioned above the DCSF initiative to encourage young learners into STEM based careers is named "Science and maths – where can they take you" (DCSF, 2008d). An alternative perspective is to see STEM activities as the bringing together of learning in at least two or more of the four STEM subjects, in a way that promotes transfer of learning. For these people STEM can be seen as a catalyst for helping teachers and learners out of their subject-based limitations into creative inter-disciplinarity. There is also debate about the relative importance of the STEM subjects within STEM. John Holman, National STEM Director, contrasts STEM in schools where it is often **SteM** with science and maths seen as more important; in the outside world **sTEm** seems a better representation. Here science and maths support and inform the development of technology and engineering, which lie at the heart of STEM (Reiss and Holman, 2007).

It is noteworthy that despite the huge amounts of money that have been spent on promoting STEM, the problematic nature of what STEM is, and the lack of consensus as to what are the desirable learning outcomes of STEM activity, at the time of writing this area has been little researched. None the less, the importance being given to STEM at a national level does suggest that there is an opportunity here to be seized by those teachers who want to develop a critical approach to ESD to collaborate with STEM orientated teachers in design and technology, engineering, science and maths.

Discussion – fitting the jigsaw together and breaking down the barriers

Before discussing how breaking down the barriers between learning in technology, science, engineering and mathematics might be addressed within an ESD frame of mind, there are three more parts of the jigsaw to note.

1. The personal, learning and thinking skills agenda (PLTS)
One key element that creates new opportunities for curriculum reform is the emergence of the PLTS agenda. The Qualifications and Curriculum Authority (QCA) developed a framework for describing personal, learning and thinking skills that applies to all young people 11-19 (QCA, 2008a). This is elaborated under six groups of skills which together with the functional skills of English, maths and ICT, will enable young people to enter work and adult life as confident and capable individuals who can make a positive contribution to society. Through the PLTS agenda teachers are asked to help their students to develop as independent enquirers, creative thinkers, reflective learners, team workers, self-managers and effective participators.

2. The extended schools agenda
Another part of the jigsaw is the government's extended schools agenda (DfES, 2005). Aimed primarily at getting joined-up services for children, it opens up opportunities for schools to be catalysts for the promotion of community well-being. It builds on the five outcomes of Every Child Matters, which are to be healthy, stay safe, enjoy and achieve, make a positive contribution, and achieve economic wellbeing. The extended schools prospectus asks (DfES, 2005) schools to ensure that by 2010 there is:

> *a varied menu of activities to be on offer such as homework clubs and study support, sport (at least two hours a week beyond the school day for those who want it), music tuition, dance and drama, arts and crafts, special interest clubs such as chess and first aid courses, visits to museums and galleries, learning a foreign language, volunteering, business and enterprise activities (p.8)*

There is an opportunity here for an imaginative school to use this as a mandate to seek action around sustainability.

3. The new National Curriculum for England
This paper makes a case for integration between some STEM learning and some ESD (education for sustainable development). It has been argued above that teachers and teacher educators might occupy some of the emerging spaces (q.v. Stephenson, 2007) brought about by educational reform and the current economic crisis for initiating a problem-based discourse on sustainability and an examination of the vested interests and powerful forces that hold the world in a thrall of unsustainable development.

In England the government is actively encouraging the development of citizenship education which also includes ESD. The new National Curriculum for learners aged 11-14 has both PLTS and ESD built is as constituent dimensions (QCA, 2008b). Education about sustainability is a specific requirement in orders for both science and design and technology, as well as in citizenship education and geography. Sustainable Development, Community Participation, Creative and Critical Thinking are named as three of the cross-curricular dimensions that all schools are encouraged to support. Finally it should be noticed that the new diplomas for learners aged 14-19 are built around the PLTS agenda. The three that relate most immediately to design and technology and engineering – Manufacturing with Product Design, Construction and the Built Environment, and Engineering itself – all demand content linked to sustainability.

Design and technology: taking the lead in blurring the boundaries
Compared to many subjects – especially science – design and technology in England has long been relatively process oriented. Emphasis is given to developing reflective practice, to problem-solving, to self managed project work and the encouragement of different modes of thinking and the meta-cognitive skills to move consciously between them – in short to many of the features of the 'new' PLTS agenda. Design and technology has long been an area of learning that can use maths and draw on scientific knowledge and method to inform design decisions. A third reason why design and technology might be a vehicle for radical curriculum reform is that discussion of values issues in general, and sustainable development in particular, are accepted already as part of the subject content. This is reflected in both the new specifications for GCSE and 'A' level. It can also be seen in curriculum initiatives such as Nuffield Design and Technology – see for example the Nuffield Primary Solutions activity 'Is the motor car a blessing or a curse?'(Nuffield Primary Design and Technology and The Royal Academy of Engineering, 2006), and the wide range of sustainable design activities developed by Practical Action in conjunction with the University of Loughborough and the Centre for Alternative Technology (Practical Action, 2007). Practical Action's websites for the Sustainable Technology Education Project (Practical Action, 2005) and the Sustainable Design Award (Practical Action, 2004) further demonstrate how design and technology can be a vehicle for ESD.

The rationale of this review of government initiatives and research literature on ESD and STEM is to argue that there is currently an opportunity for the professional community of design and technology teachers to take a lead in developing STEM in their schools, picking up design contexts via analysing the demands of sustainable development. These could include more obvious

examples such as energy audits, experiments with different sorts of insulation, building devices to capture the energy from sun or wind – or even people going up and down stairs. Such activity could be linked to discussions in the classroom, debates in school council and action to make the school and the local community more sustainable. Equally there are opportunities around food, purchasing, waste, transport, use of water.

The flexibility offered by the new Key Stage 3 curriculum and the project-based learning in the diploma mean that sustainability-inspired STEM projects, rooted in the school and/or the community, could satisfy objectives of Every Child Matters, the Extended Schools offer, the policies on ESD and STEM and PTLS. But for this to be effective there needs to be a willingness to encourage controversy and debate as these real issues are addressed (q.v. Bonnett, 2003, Huckle, 2006 and Stevenson, 2007); this is something that many school leaders and governing bodies might well not want. On the other hand, this might be an opportune moment to break down barriers not just between subjects, but also between learning in school and action in the outside world.

It is appropriate, however, to finish on a cautious note. If the professional community of design and technology teachers is to play a leading role in pulling together ESD, STEM and PLTS as argued for above, it is important to recognise that CPD to achieve this is in itself problematic. Pitt and Lubben (2009) undertook an investigation into the take-up of the Sustainable Design Award by design and technology teachers in England, Wales and Netherlands. This was an intervention in Post-16 technology education aimed at introducing principles of sustainable design into students' work. The effect of the CPD was varied and seemed to correlate with teachers' initial motivation in getting involved. Pitt and Lubben propose a typology of teachers whom they call 'surfers', 'seekers' and 'devotees'. 'Surfers' are not really interested in education for sustainable development, and move quickly on to something else that is being promoted by central government or an educational challenge by a company. The 'seekers' are looking for coherence in their teaching and find it in sustainable design. The 'devotees' are a more complex group; they are already committed to teaching about sustainability and want to do it better. But significantly there appears to be a tipping point in which this last group of teachers begin to apply the principles of sustainability in their own practice, and ask questions of themselves, their students and their schools. These questions lead to a critical discourse on why things are the way they are. This resonates with Bonnetts 'frame of mind' approach to sustainability (Bonnett, 2003) and Webster's three concentric circles (Webster 2004 – see Figure 1). If STEM is to be used as a context for ESD, taking advantage of the opportunities or 'Stevenson spaces' outlined above, it will be necessary to engage the teachers involved in a carefully constructed dialogue to bring out why they wish to do so. Crucially this will involve an exploration of values – not always the most comfortable of occupations. Almost certainly, blurring the boundaries will be painful.

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Appendix

Doorways into Sustainable Schools (DCSF 2008)

Doorway	Curriculum	Campus	Community	Target
1. Food and Drink	Schools can use the curriculum to cultivate the knowledge, values and skills needed to address the health and sustainability issues of food and drink, and reinforce this through positive activities in the school and in the local area.	Schools can review the impact of their food and drink choices on human health, the environment, the local economy and animal welfare, and work with suppliers to identify produce that meet the highest standards.	Schools can use their school grounds, communications, services, contracts and partnerships to promote awareness of the wider impacts of food and drink choices among their stakeholders.	By 2020, the Government would like all schools to be model suppliers of healthy, local and sustainable food and drink. Food should, where possible, be produced or prepared on site. Schools should show strong commitments to the environment, social responsibility and animal welfare. They should also seek to increase their involvement with local suppliers.
2. Energy and water	Schools can use the curriculum to cultivate the knowledge, values and skills needed to address energy and water stewardship – both at a local and a global level.	Schools can review their use of energy and water and establish policies for monitoring and reducing their use through good management and the deployment of appropriate technologies.	Schools can use their communications, services, contracts and partnerships to promote awareness of sustainable energy and water use among their stakeholders.	By 2020, the Government would like all schools to be models of energy efficiency, renewable energy use and water management. They should take the lead in their communities by showcasing wind, solar and bio-fuel energy, low-energy equipment, freshwater conservation, use of rainwater and other measures.
3. Travel and traffic	Schools can use the curriculum to cultivate the knowledge, values and skills needed to address travel and traffic issues, and reinforce this through positive activities in the school and in the local area.	Schools can review the impact of their travel behaviour and establish policies and facilities for promoting safe walking and cycling, car sharing and public transport to lessen their environmental impact and promote healthier lifestyles.	Schools can use their communications, services, contracts and partnerships to promote awareness of travel decisions among their stakeholders.	By 2020 the Government would like all schools to be models of sustainable travel, where vehicles are used only when absolutely necessary and where there are exemplary facilities for healthier, less polluting or less dangerous modes of transport.
4. Purchasing and waste	Schools can use the curriculum to cultivate the knowledge, values and skills needed to address sustainable consumption and waste issues, and reinforce this through positive activities in the school and in the local area.	Schools can review their purchasing and waste choices in order to reduce whole-life costs, support the local economy, and establish policies for reducing, recycling, repairing and reusing as much as possible.	Schools can use their communications, services, contracts and partnerships to promote awareness of sustainable consumption and waste minimisation among their stakeholders.	By 2020 the government would like all schools to be models of resource efficiency by using low impact goods from local suppliers that minimise (or eliminate) packaging and that are produced with high environmental and ethical standards, and by recycling, repairing and reusing as much as possible.

5. Buildings and grounds	Schools can use the curriculum to cultivate the knowledge, values and skills needed to appreciate the link between the built environment, human well-being and nature, and reinforce this through positive activities in the school and local area.	Schools can review the way their estate influences the behaviour, well-being and learning of pupils and staff, and take steps to enhance interior and exterior spaces for health, achievement and play, and to provide safe habitats for local wildlife.	Schools can use their communications, services, contracts and partnerships to promote the importance of sustainable design and practices in buildings and grounds among their stakeholder.	By 2020 the Government would like all school buildings - old and new - to make visible use of sustainable design features and, as opportunities arise, to choose building technologies, interior furnishings and equipment with a low impact on the environment. We would like all schools to develop their grounds in ways that help pupils learn about the natural world and sustainable living, for example, through food growing and biodiversity conservation.
6. Inclusion and participation	Schools use the curriculum to cultivate the knowledge, values and skills needed to promote inclusion and participation, and reinforce this through positive activities in the school and local area.	Schools can review their approach to promoting inclusion and participation, and establish policies that promote a culture of mutual respect and care such that all pupils enjoy their day-to-day experience of school.	Schools can use their communications, services, contracts and partnerships to promote the values of inclusion and participation among their stakeholders.	By 2020 the Government would like all schools to be models of social inclusion, enabling all pupils to participate fully in school life while instilling a long-lasting respect for human rights, freedoms, cultures and creative expression.
7. Local well-being	Schools can use the curriculum to cultivate the knowledge, values and skills needed to understand and address local issues and challenges, and reinforce this through positive activities in the school and local area.	Schools can consider the challenges facing their local surroundings and community, and identify areas where the school's decisions, practices and services can contribute to local well-being.	Schools can use their communications, services, contracts and partnerships to promote awareness of local environmental and social challenges among their stakeholders.	By 2020 the Government would like all schools to be models of good corporate citizenship within their local areas, enriching their educational mission with activities that improve the environment and quality of life of local people.
8. Global citizenship	Schools can use the curriculum to cultivate the knowledge, values and skills needed to act as globally aware citizens, and reinforce this through positive activities such as school partnerships and exchanges.	Schools can review the extent to which their management and purchasing choices affect people and the environment globally, and establish policies that reflect their commitment to global citizenship.	Schools can use their communications, services, contracts and partnerships to promote respect for the well-being of other cultures, countries and the global environment among their stakeholders.	By 2020 the Government would like all schools to be models of good global citizenship, enriching their educational mission with activities that improve the lives of people living in other parts of the world.

Source: DCSF (2008) Sustainable Schools National Framework http://www.teachernet.gov.uk/sustainableschools/framework/framework_detail.cfm?id=1