

**Using e-learning for student sustainability literacy :  
framework and review**

DIAMOND, Susannah and IRWIN, Brian

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/10755/>

---

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

**Published version**

DIAMOND, Susannah and IRWIN, Brian (2013). Using e-learning for student sustainability literacy : framework and review. *International Journal of Sustainability in Higher Education*, 14 (4), 338-348.

---

**Copyright and re-use policy**

See <http://shura.shu.ac.uk/information.html>

# Using e-learning for student sustainability literacy: framework and review

**Susannah Diamond and Brian Irwin**

*Student and Learning Services, Sheffield Hallam University, Sheffield, UK*

**Submitted 14-Sep-2011**

**Revised 14-Feb-2012**

## **Abstract**

**Purpose** – The paper aims to explore staff practices in using e-learning to embed sustainability literacy, highlight best practice and determine areas for improvement.

**Approach** – A framework of four areas for developing SSL was proposed as a basis for analysing practice. A literature review then explored the extent to which e-learning is used to support embedding SSL in the curriculum, and the types of e-learning currently in use for this.

**Findings** – E-learning tools were most frequently used to provide flexible access to information, followed by support for communication and collaboration, and were less frequently used for the development of specific skills, personal identity and confidence.

**Research limitations and implications** – The sample of case studies provided only limited evidence. A survey of practitioners could be undertaken to explore and validate the issues raised by the literature review.

**Practical implications** – The review highlighted scope for a pedagogical shift away from using e-learning for information delivery and practical communication, and towards supporting rich, student-centred forms of learning in both blended and distance learning modes.

**Social implications** – This shift would create more powerful learning experiences for students, more effectively develop students' personal identities and skills, and yield graduates who are more confident in their ability to create more sustainable futures.

**Value** – This paper will be of value to academic staff and educational developers looking to develop practice in embedding SSL in teaching and learning, and to harness the potential of e-learning.

**Keywords** – sustainability literacy, e-learning, pedagogy, student-centred, skill development, learner identity

**Paper type** – Conceptual paper

# 1. Introduction

To achieve sustainability for human and ecological systems, universities must "become leaders in the movement to prevent global ecological collapse" (Moore, 2005, p326). The "development of sustainability literacy as a 'core competence'" is a priority at the heart of this (Dawe *et al.*, 2005, p4). This paper focuses on how student sustainability literacy (SSL) can be embedded in the curriculum in Higher Education (HE), and in particular, explores current practice in using e-learning to achieve this.

Whilst there is already literature both on developing SSL, and on the value of e-learning, little has been published about the specifics of using e-learning to support SSL. E-learning remains an area of interest and development that can provide effective and imaginative ways to embed SSL.

This paper takes an empirical-analytical approach to exploring how e-learning is currently used to develop SSL: outlining the theory and practice of SSL and e-learning pedagogies, proposing a framework for analysing SSL practice, reviewing current practice, and making recommendations for further research which may assist in improving practice in this area.

## 2. Background

### 2.1. Sustainability literacy

Guidance about embedding SSL in education has developed considerably over the last decade, but remains a complex conceptual field, with a variety of definitions and frameworks for analysing practice.

We define sustainability literacy as: having the understanding, skills, attitudes and attributes to take informed action for the benefit of oneself and others, now and into a long term future (adapted from Forum for the future, 2004). This definition echoes the teaching of sustainable development but avoids rather focusing only on developing conceptual understanding or only focusing on disciplines of environmental science, and specifically aims to foster the ability of students in any discipline to take effective and appropriate action. This definition is arrived at by synthesising various learning outcomes and characteristics as described below.

Authors such as Moore (2005) and Dawe *et al.* (2005) provide useful guidance in considering the university context for change and highlighting staff attitudes and approaches. However, it is more useful to focus on learning outcomes as they are particularly important for academic staff and inform both the design of the curriculum and interactions with students.

The Centre for Sustainable Futures describe four kinds of learning outcomes: "knowledge/understanding", "cognitive/intellectual skills", "key/transferable skills", and "practical skills" (Sterling, 2008, pp. 6-7). This provides a valuable foundation, and the approach is supported by others who focus on competencies, e.g. Brundiers *et al.* (2010). These learning outcome types can be split into conceptual development and skill development outcomes. Conceptual development ensures that learners have an understanding of the interrelated nature of complex and seemingly intractable sustainability issues in the real world, and the pantheon of cognitive, personal and practical skills are clearly fundamental to the graduate toolkit. More specifically, skill

development for SSL could include deepening cognitive skills (e.g. holistic, interdisciplinary, critical, and systems thinking) and increasing competence in practical skills (e.g. analysis of environmental or social impacts). However two further areas of importance for developing SSL are mentioned in the literature but are not included in these competency outcomes: student identity and the development of confidence.

Identity development involves the consolidation of personal values and identity aligned with achieving sustainability. A commitment to taking action is important, and "changes in values, attitudes and behaviours" are expected as outcomes of effective education for sustainability (Warburton, 2003, p. 50). Similarly, Bonnett (2010) links attitudes towards the environment with a sense of personal identity.

Development of confidence is essential in ensuring that individuals are empowered (Stibbe & Luna, 2009) and "ready to make the leap from 'I know' to 'I care' to 'I'll do something' " (Cotgrave and Kokkarianen, 2011, p. 212, adapted from Orr, 1992). This belief in the likelihood that they can modify personal, social and business processes which impact on sustainability therefore relates to self-efficacy and self-confidence. Confidence is better described as an attribute than a skill, and as such may need different approaches to student development, and therefore belongs in a category of its own.

Elaborating on this summary of relevant work and on our definition, we arrive at the following four developmental areas required for SSL to be successful. These provide a framework which will be used to analyse the approaches taken in the literature review:

- a) conceptual awareness of sustainability issues in the real world
- b) personal identity and values aligned with achieving sustainability
- c) competence in skills which can contribute to achieving sustainability
- d) confidence in an ability in contribute to achieving sustainability.

Developing student identity, cognitive processes and confidence are challenging teaching tasks, and pedagogical transformation may be needed to enable these within HE contexts. Many recommendations (e.g. in Moore, 2005) align with general advances in pedagogy: such as inclusion of reflective discussion, or problem-based learning (PBL). Three more specific recommendations are: personal disclosure or modelling of practice by educators to assist in developing personal values of students, interdisciplinary learning (involving students from contrasting subjects) to promote "deep" and critical learning (Warburton, 2003, p. 44), and using real-world learning to reconnect learners with reality.

## **2.2. E-learning**

The term e-learning can encompass all electronically supported learning and teaching, i.e. networked and stand-alone. E-learning can be used to deliver information and instruction and also to encourage social participation or facilitate constructive learning activities (adapted from Tavangarian *et al.*, 2004). A strong body of theory and practice has established how e-learning can support good practice in undergraduate education: The principles build on key "traditions" of pedagogical thought such as constructivism, social constructivism, activity theory, and theories of experiential learning (Beetham and Sharpe, 2007, p. 8), and stress the importance of interaction, communication, collaboration, engagement, and feedback (Chickering and Ehrman, 1996; IHEP, 2000) for student-centred learning.

Although relevant experts (e.g., Laurillard, 2002, Naismith *et al.* 2004, and Mayes and de Frietas, 2004) have mapped relationships between different pedagogical theories and learning activities and particular e-learning technologies or tools, such mappings should be used with caution: "An important consideration is not what tool to use, but how to use it" (Littlejohn and Pegler, 2007, p. 96). "Each activity type can be supported by more than one tool" (Littlejohn and Pegler, 2007, p. 98). Nevertheless, we give examples of how the four key aspects of SSL could be supported with e-learning:

- a) Students' conceptual understanding of complex sustainability challenges could be promoted through both assimilative and productive approaches. Exposure to media documentaries can stimulate opinion and provoke debate; scaffolded enquiry processes can build understanding and knowledge. Students could develop guidance or resources to share with a community project, or use a blog for planning and reporting on action research as a postgraduate professional. Furthermore, serious games show promise for embedding SSL, by emotionally engaging students in complex sustainability issues (Scheffran, 2000; Dieleman and Huisingsh, 2006).
- b) The value and potential of e-learning technologies in developing values and identity is well established. Using technologies to support dialogue within a learning community assists the development of personal identity (Mayes, 2001; Wenger, 1998; Gray, 2004). Communication between students and academic staff via email and asynchronous discussion within a managed learning environment (MLE) strengthens student engagement and their focus on their goals (Chickering and Ehrman, 1996). Other approaches include using e-portfolios to develop personal narratives in relation to sustainability, or using the cross-cultural debate of international online forums to develop clarity about personal values.
- c) PBL (whether real or simulated) is recognised as effective in developing competence in personal skills. Examples of appropriate e-learning approaches to support PBL include internet research and data manipulation tools, communication between students and external experts or clients (including asynchronous reflective discussion or synchronous decision making), and simple approaches to authentic learning and simulation (Herrington *et al.*, 2003). MLEs can provide a range of support and guidance: scaffolding enquiry processes, facilitating sharing of resources and project documentation, and allowing tutor observation of project progress. Given the value of real-world learning for fostering SSL, blended modes which combine work placements or community-based learning with e-learning facilitation of independent and collaborative learning enquiries are particularly appropriate methods of course delivery.
- d) Lastly, the development of student confidence can be supported by e-learning technologies in various ways. Viewing digital case studies of successful change projects can strengthen belief in the achievability of sustainability. Acting as professionals through PBL can strengthen students' self-efficacy. Also MLEs can facilitate delivery of immediate and meaningful peer or tutor feedback, and support personal evaluation of skills and abilities as part of personal development planning.

The development of e-learning continues to unfold. Democratisation of content creation and personal mobile access to content has developed over the last decade (Beetham and Sharpe, 2007) and conceptualisation of effective e-learning has broadened from narrow "content-led" approaches to become more participative (Brenton, 2009, p. 97). As technologies become more "unobtrusive" and "ubiquitous" (Kukulska-Hulme and Traxler,

2007, p. 42), they are likely to prove more powerful in supporting work-based and community learning.

### 3. Methodology

A review of teaching approaches was undertaken to explore the types of e-learning currently used in embedding sustainability in HE curricula. This focused on examples of practice rather than theoretical assertions, and sought recent examples (from 2000 onwards) to reflect the fast-changing developments of the field.

Examples were obtained by searching a range of sources: The search began with a few books, journals and websites with specific relevance, e.g., the *Journal of Education for Sustainable Development* and the Higher Education Academy's resources on sustainability ([www.heacademy.ac.uk/education-for-sustainable-development](http://www.heacademy.ac.uk/education-for-sustainable-development)). Further searches were also carried out via ProQuest, the BEI, ERIC, and Google Scholar. Search terms such as "*sustainability literacy*", and "*e-learning*" were developed in a grounded and iterative way during the search.

34 relevant examples were found. These included quality peer-reviewed articles and grey literature such as practitioner websites, and ranged from evaluative papers through to semi-formal case studies. The framework for SSL outlined above (conceptual development, identity development, skill development, and developing confidence) was used to categorise these examples according to their ability to use e-learning to support the development of different aspects of SSL. A fifth category of 'Other' was also used to cover other mentions of e-learning which were not explicit or not relevant e.g. value for money. Multiple categories were applied as appropriate.

### 4. Findings

E-learning is clearly used in many courses to help to develop SSL. The examples covered a wide range of subject areas, across undergraduate and postgraduate HE courses, and a diversity of e-learning tools was evident. By far the most common examples of e-learning tools were in providing flexible access to information (via the Intranet, VLEs, CDs etc.). The second group supported communication and collaboration (via email, wikis, group support systems, etc.). The least common tools were generic or bespoke software used to develop discipline specific skills (e.g. the lifecycle analysis of environmental footprints). E-learning is used to support the four categories of SSL in various ways:

*Conceptual development.* Twenty-three examples in this category demonstrated a range of e-learning approaches which included didactically informing students, provoking reflective discussion, and involving students as active co-creators of knowledge, e.g.:

- PowerPoint was used in presentations to introduce concepts and exercises (Snowdon, 2007)
- Video clips were used to illustrate issues and provoke discussion (Roberts, 2007)
- Students contributed to an ongoing bank of study materials (Halstead, 2007).

Unfortunately, most examples identified in this category embody more didactic, passive and teacher-centric modes of information delivery, e.g. packaged interactive training materials, web resources, and CD-ROMs.

*Identity development.* The eight examples identified in this category spanned three activity types (obtaining feedback on actions, publication of work and keeping learning logs), e.g.:

- An online role-playing game illustrated the impacts of different behavioural strategies (Yanarella *et al.*, 2000)
- After students developed personal eco-philosophical frameworks, a research forum allowed publication of their work (Stibbe, 2007)
- Reflective personal learning logs were used by trainee teachers (Ross and Littledyke, 2007).

*Skill development.* Seven examples showed how e-learning is used to support both discipline-specific domains and cross-discipline thinking skills, e.g.:

- Developing or using carbon footprint calculators fostered awareness of lifestyle impacts, and provided skills in deriving underlying data or calculations (Gordon, 2010)
- Skills in critically examining evidence were developed in combination with use of electronic resource gateways, and case studies (Chambers, 2007)
- Holistic thinking skills were fostered via an online learning community which included students and external sustainability practitioners (McEwen, 2007).

*Developing confidence.* Five examples described opportunities for students to develop confidence such as by sharing opinions, publishing work, and developing skills, e.g.:

- Following discussion in a private online forum, course participants published reports via a public conference system (Strandberg and Brandt, 2001)
- Students used group wikis to develop guidance on sustainable practice for a fictitious company (Payne, 2009)
- Interdisciplinary student teams used a variety of e-learning tools to research and champion practical projects in community contexts (Bacon *et al.*, 2011).

*Other.* Often the examples in this category simply mentioned e-learning for reasons which sit outside the four categories above. These included providing flexible access to information, supporting communication, valuing e-learning simply as pedagogic innovation, reducing the footprint of LTA, or evidencing reductions in students' personal ecological footprint. Although the latter may be gratifying, HE courses do not usually aim to change personal behaviour (apart from the development of professional integrity). This category also included authors who made recommendations about practice rather than providing actual examples.

The review therefore indicated that e-learning is often used in the context of developing SSL. However, there is an imbalance in tool type being used, such that e-learning is frequently used in transmissive modes of delivery rather than student-centric, constructivist modes. In addition, there was less evidence that e-learning was being used to develop students' personal identity, competence and confidence than that it was being used for more basic development of conceptual understanding. Nevertheless, more recent case studies (e.g. Pearce, 2009; Bacon *et al.*, 2011) indicate promising developments, both in the e-learning approaches used, and in the categories of SSL addressed.

## 5. Discussion

The four developmental areas for SSL (conceptual development, identity development, skill development, and the development of confidence) have been of value in analysing current practice in developing SSL, and may also help academic staff in embedding SSL development in their practice, and particularly understanding the potential of different types of e-learning to support SSL. The examples of SSL practice illustrate the range of e-learning approaches which can be applied in the context of SSL, but we will discuss the implications of the imbalance in types of tools used, the imbalance in the aspects of SSL supported, and the quality of the case studies available.

We focus first on the imbalance in tool types. Aligning with recent pedagogic developments and e-learning research, a wide range of e-learning tools and approaches are now in use across the HE sector. Use of content-free, participative e-learning tools such as discussion boards, wikis etc., allows more effective expression and knowledge construction to take place. The imbalance in tool type in our review therefore provides a clue that the use of e-learning for SSL does not yet exploit its full potential. Although the examples demonstrated application of a wide range of pedagogic approaches to SSL, it was unclear whether the use of e-learning was underpinned by a similar range of pedagogies. These results match findings by others, e.g., in nursing and health science disciplines "engagement with e-learning was predominantly at an instructivist level" (Moule *et al.*, 2010, p. 86). The historical bias towards didactic information delivery or 'interactive' training resources which only allow choice and experimentation within a limited range of choices is cause for concern. However a shift away from content-led e-learning is demonstrated by more recent case studies we reviewed and should foster more powerful and effective learning experiences for students.

The imbalance in the aspects of SSL being supported with e-learning is of similar importance. Although knowledge and understanding are key to recognising the need for systemic change, this will not guarantee development of the personal commitment, skills, and self-belief which are also essential. The range of examples highlighted in the findings demonstrate ways that these more advanced aspects could also be supported with e-learning. Widening out the application of e-learning to encompass the development of skills, identity, and confidence would contribute immensely to the development of graduates who are capable of contributing to achieve more sustainable futures.

An unanticipated outcome of the review was the realisation that there is a scarcity of literature judging the effectiveness of e-learning in developing SSL. This may be because:

- E-learning technologies are seen as endemic and not requiring specific mention
- SSL is seen as too complex, profound or personal to be addressed through e-learning
- Practitioners have concerns about the environmental footprint of e-learning itself.

The sources were often a-theoretical, and demonstrated what is valued by practitioners in "story-telling" about teaching practice. Most examples focused on the embedding of SSL, instead of explaining why particular e-learning techniques were chosen or commenting on their effectiveness in embedding SSL. This may have led to errors in categorisation, especially where tools and techniques were used in non-standard ways. Not surprisingly, the more transparently and successfully e-learning is embedded into the learning experience, the more difficult it becomes to partition out the contribution which e-learning makes in developing SSL.



A more in depth study into SSL teaching practice across the sector would be valuable in understanding why case studies make little mention of the effectiveness of e-learning, testing whether there is really an imbalance in the types of tools used and in the areas of SSL supported with e-learning, and in exploring the effectiveness of e-learning in developing SSL. Such research could assist more mature practice in using e-learning in developing the more advanced aspects of SSL (student identity, competence and confidence). This would fully leverage the potential of e-learning, enhance the development of blended and distance modes of course delivery for SSL, and provide opportunities for students to develop as confident professionals.

## 6. Conclusions

The review proposed a framework for analysing practices in developing SSL. Application of this framework to a range of examples of published practice identified a range of uses of e-learning tools and approaches. The majority of these, however, took the form of supporting conceptual development through didactic information delivery. However, a more mature use of e-learning tools provides many more possibilities for developing SSL than were found in the review.

We therefore make two recommendations for academic staff and educational developers looking to develop their practice and to harness the potential of e-learning techniques effectively in embedding sustainability literacy in teaching and learning. Firstly, use of e-learning should be shifted towards supporting more student-centred modes of learning as these can be effective in developing difficult areas of SSL such as student identity, cognitive processes, and confidence. Secondly, use of e-learning should be widened to more effectively support the development of personal identity, skill development and professional confidence in applying skills in real-world contexts.

There is clearly overlap in these recommendations, and beneficial synergy to be gained in implementing these changes together. These pedagogical shifts could create more powerful learning experiences for students, in both blended and distance learning modes, and foster graduates who are more confident in their ability to create more sustainable futures.

Further research should be undertaken to explore and validate the issues raised by the literature review. More rigorous evaluations of the effectiveness of e-learning in developing SSL could then be undertaken, particularly to methodically explore the potential of participative approaches to develop advanced aspects of SSL.

.

### References

- Bacon, C., Mulvaney, D., Ball, T., DuPuis, M., Gliessman, S., Lipschutz, R. and Shakouri, A. (2011) "The creation of an integrated sustainability curriculum and student praxis projects", *International Journal of Sustainability in Higher Education*, 12(2) 193-208 Accessed 16/06/2011 from <http://dx.doi.org/10.1108/14676371111118237>
- Beetham, H. and Sharpe, R. (2007), "An introduction to rethinking pedagogy for a digital age", in Beetham, H. and Sharpe, R. (Eds.) *Rethinking Pedagogy for a Digital Age*. Routledge, London, pp 1-10.

- Bonnett, M. (2010) "Education for Sustainability as a Frame of Mind", *Environmental Education Research*, 8(1), 9-20, Accessed 09/08/2011 from <http://dx.doi.org/10.1080/13504620120109619>
- Brenton, S. (2009), "E-learning - an introduction", in H. Fry and S. Ketteridge, *A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice*, Routledge, New York, pp 85-98
- Brundiers, K., Wiek, A. and Redman, C. (2010), "Real-world learning opportunities in sustainability: from classroom into the real world", *International Journal of Sustainability in Higher Education*, 11(4) 308-324. Accessed 16/06/2011 from <http://dx.doi.org/10.1108/14676371011077540>
- Chambers, F. (2007), "Environmental change and sustainability: Lessons from the past", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 90-95. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Chickering, A.W. and Ehrmann, S.C. (1996), "Implementing the seven principles: technology as lever", *AAHE Bulletin*, 49(2), 3-6. Accessed 16/06/2011 from <http://www.aahea.org/bulletins/articles/sevenprinciples.htm>
- Cotgrave, A. and Kokkarinen, N. (2011) Promoting sustainability literacy in construction students: Implementation and testing of a curriculum design model, *Structural Survey* 29(3) 197-212  
<http://dx.doi.org/10.1108/02630801111148185>
- Dawe, G., Jucker, R. and Martin, S. (2005), "Sustainable development in Higher Education: Current practice and future developments". Report for the Higher Education Academy, York: HEA. Accessed 13/07/2011 from <http://www-new2.heacademy.ac.uk/assets/documents/sustainability/sustdevinHEfinalreport.pdf>
- Dieleman, H. and Huisingsh, D. (2006), "Games by which to learn and teach about sustainable development: exploring the relevance of games and experiential learning for sustainability", *Journal of Cleaner Production* 14 837-847. Accessed 16/06/2011 from <http://dx.doi.org/10.1016/j.jclepro.2005.11.031>
- Forum for the Future (2004) Sustainability literacy: knowledge and skills for the future, Report of a consultation workshop. Accessed 20 August 2011 from <http://www.dynamo.tno.nl/efmn/download.asp?id=1040>
- Gordon, N. (2010), "Sustainable Information Technology Awareness", *Italics*, 9(2) 4 pp. Accessed 16/06/2011 from <http://www.ics.heacademy.ac.uk/italics/vol9iss2.htm>
- Gray, B. (2004), "Informal Learning in an Online Community of Practice", *Journal of Distance Education*, 19(1) 20-35. Accessed 16/06/2011 from <http://www.jofde.ca/index.php/jde/article/view/103>
- Halstead, P. (2007), "Liberty, equality and fraternity: Integrating sustainability into law teaching", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 116-126. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Herrington, J., Oliver, R. and Reeves, T. (2003), "Patterns of engagement in authentic online learning environments", *Australian Journal of Educational Technology*, 19(1) 59-71. Accessed 16/06/2011 from <http://www.ascilite.org.au/ajet/ajet19/herrington.html>
- IHEP (2000), "Quality on the line: Benchmarks for success in internet-based distance education", *The Institute for Higher Education Policy*. Accessed 16/06/2011 from <http://www.ihep.org/Publications/publications-detail.cfm?id=69>

- Kukulska-Hume, A. and Traxler, J. (2007), "Mobile Teaching and Learning", in Kukulska-Hume, A. and Traxler, J., (Eds.) *Mobile Learning, A handbook for educators and trainers*. Routledge, New York, pp 25-44
- Laurillard, D. (2002), *Rethinking University Teaching: A conversational framework for the effective use of learning technologies*, 2nd edn., London; New York: Routledge/Falmer.
- Littlejohn, A. and Pegler, C. (2007), *Preparing for Blended E-learning*, Routledge, Abingdon.
- Mayes, T. (2001) "Learning Technology and Learning Relationships". In Stephenson, J. (Ed) *Teaching and Learning Online: Pedagogies for New Technologies*, Kogan Page, p16-26
- Mayes, T. and de Freitas, S. (2004), "Review of e-learning theories, frameworks and models. Stage 2 of the e-learning models desk study", Bristol: JISC. Accessed 16/06/2011 from [www.jisc.ac.uk/uploaded\\_documents/Stage%20%20Learning%20Models%20\(Version%201\).pdf](http://www.jisc.ac.uk/uploaded_documents/Stage%20%20Learning%20Models%20(Version%201).pdf)
- McEwen, L. (2007), "Education for sustainable development for taught postgraduates: Designing effective active co-learning environments for on-site and distance learning students", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 21-31. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Moore, J. (2005) "Seven recommendations for creating sustainability education at the university level: A guide for change agents", *International Journal of Sustainability in Higher Education*, 6(4), 326-339  
Accessed 16/06/2011 from <http://dx.doi.org/10.1108/14676370510623829>
- Moule, P., Ward R. and Lockyer, L. (2010), "Issues with e-learning in nursing and health education in the UK: are new technologies being embraced in the teaching and learning environments?" *Journal of Research in Nursing* 16(1) 77-90, Accessed 16/06/2011 from <http://dx.doi.org/10.1177/1744987110370940>
- Naismith, L., Lonsdale, P., Vavoula, G. and Sharples, M. (2004), "Literature Review in Mobile Technologies and Learning" Report 11 for Futurelab. Accessed 16/06/2011 from [http://archive.futurelab.org.uk/resources/documents/lit\\_reviews/Mobile\\_Review.pdf](http://archive.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf)
- Payne L. (2009), "Using a wiki to support sustainability literacy", *Italics*, 8(1), 45-52  
Accessed 16/06/2011 from <http://www.ics.heacademy.ac.uk/italics/vol8iss1/pdf/ItalicsVol8Iss1Feb2009.pdf#page=46>
- Pearce, J. (2009) Appropedia as a tool for service learning in sustainable development, *Journal of Education for Sustainable Development*, 3(1) 45-53.  
Accessed 16/06/2011 from <http://dx.doi.org/10.1177/097340820900300112>
- Roberts, C. (2007), "Managing water: Learning about, and learning for sustainable development", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 58-66.  
Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Ross, K. & Littledyke, M. (2007), "A science module for Level 1 Primary BEd trainee teachers based on sustainable development principles", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 96-106. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>

- Scheffran, J. (2000), "The dynamic interaction between economy and ecology: Cooperation, stability and sustainability for a dynamic-game model of resource conflicts." *Mathematics and Computers in Simulation* 53(4-6) 371-380. Accessed 16/06/2011 from [http://dx.doi.org/10.1016/S0378-4754\(00\)00229-9](http://dx.doi.org/10.1016/S0378-4754(00)00229-9)
- Snowdon, R. (2007), Sustainable landscape design: Introducing permaculture into landscape architecture design, in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 127-132. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Sterling, S. (2008) *Sowing Seeds, How To Make Your Modules A Bit More Sustainability Oriented*, Centre for Sustainable Futures, University of Plymouth. Accessed 07/03/2012 from <http://uplace.org.uk:8080/dspace/handle/10293/1125>
- Stibbe, A. (2007), "Developing critical awareness language skills for sustainability: A transdisciplinary approach", in Roberts, C. and Roberts J. (Eds.) *Greener by Degrees: Exploring sustainability through Higher Education curricula*. Cheltenham: GDN. pp. 74-80. Accessed 16/06/2011 from <http://insight.glos.ac.uk/tli/resources/toolkit/resources/Pages/GreenerbyDegrees.aspx>
- Stibbe, A. & Luna, H. (2009), Introduction in Stibbe, A., (Ed) *The Handbook of Sustainability Literacy: Skills for a changing World*, (pp 9-16). Green Books, Dartington
- Strandberg, L. and Brandt, N. (2001), "Sustainable development in theory and practice - An inter-Nordic Internet course for regional and local officials and practitioners", *International Journal of Sustainability in Higher Education*, 2(3), 220-225. Accessed 16/06/2011 from <http://dx.doi.org/10.1108/EUM0000000005622>
- Tavangarian, D, Leypold, M., Nölting, K., Röser, M. and Voigt, D. (2004), "Is e-learning the solution for individual learning", *Electronic Journal of e-Learning* 2(2) 273-280. Accessed 16/06/2011 from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.116.8017&rep=rep1&type=pdf>.
- Warburton, K. (2003), "Deep learning and education for sustainability", *International Journal of Sustainability in Higher Education*, 4(1) 44-56. Accessed 16/06/2011 from <http://dx.doi.org/10.1108/14676370310455332>
- Wenger, E. (1998), *Communities of Practice: Learning, meaning and identity*, Cambridge University Press, Cambridge.
- Yanarella, E., Levine, R. and Dumreicher, H. (2000), "The space of flows, the rules of play, and sustainable urban design: The sustainability game as a tool of critical pedagogy in higher education", *International Journal of Sustainability in Higher Education* 1(1) 48-66. Accessed 16/06/2011 from <http://dx.doi.org/10.1108/1467630010307093>

### About the authors

Susannah Diamond is an educational developer at Sheffield Hallam University and Fellow of the Higher Education Academy. Her research interests include authentic learning, the application of emerging learning technologies, and sustainability in education. Susannah Diamond is the corresponding author and can be contacted at: [s.m.diamond@shu.ac.uk](mailto:s.m.diamond@shu.ac.uk)

Brian Irwin is Head of Technology Enhanced Learning at Sheffield Hallam University. His research interests include staff engagement with e-learning and the effect of technology on student experiences of feedback.