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Emerald Article: Sustainable development, education and literacy
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Abstract

Purpose – To distinguish sustainable development education from environmental education and stress the importance of problem-based interdisciplinary learning to sustainable development education.

Design/methodology/approach – A range of published works relating to sustainable development education are critiqued, an introduction to complexity theory is given and related to sustainable development education, and a case study is provided to demonstrate an example of incorporating sustainability into course delivery and to demonstrate problem-based interdisciplinary learning.

Findings – Our discussion supports our claim that reconciling sustainability and development requires a complex interdisciplinary approach beyond that found in some areas of traditional environmental education.

Research limitations/implications – Our literature search is not exhaustive and focuses on sustainable development education. A much greater body of literature relating to environmental education exists.

Practical implications – Our discussion and case study suggests practitioners designing and teaching sustainable development related programs should incorporate an interdisciplinary approach and allow for problem-based applied learning to take place.

Originality/value – This paper distinguishes sustainable development education from environmental education and suggests practical courses of action for initiating sustainable development education in a meaningful manner.

Keywords Sustainable development, Education

Paper type General review

Introduction

The role of sustainable development in education has been the subject of a heated debate (Hopkins, 1998; Rassool, 1999; Jickling, 2000; Foster, 2001; Gough, 2002; Bonnett, 1999). Critics have argued that sustainable development is an inappropriate focal point for developing curriculum as it is too normative, ambiguous and ineffective at solving the complex problems that will face the next generation (Jickling, 2000). These critics misrepresent the proposed role of sustainable development in education. Sustainable development literacy can be measured in terms of acquiring a set of critical skills, which do provide a sound framework for education. These skills reflect the complex nature of social-ecological reactions, thus interdisciplinary appreciation and skills are integral to sustainable development literacy, epistemology and research. For these reasons, its study is, therefore, process-based as well as facts based; these tools must be flexible enough to generate appropriate responses specific to each individual situation and applied enough to allow engagement of global problems at the local level.

Moreover, since sustainable development concerns both human and natural systems, and as these systems are now co-evolving (Norgaard, 1994; Dale, 2001), its study must be grounded in complex adaptive systems epistemology, which is in itself an interdisciplinary tool. These factors sufficiently differentiate sustainable development education from traditional discipline-focussed study and largely differentiate what compromises sustainable development literacy from the broader category of environmental literacy.

There are hundreds of definitions for sustainable development (Dale, 2001). Several thinkers see this ambiguity as problematic; Rees (1989) argued that a prerequisite to developing sustainable policies is a satisfactory working definition of the concept, and Jickling (1994) argued that sustainable development education requires an adequate conceptualisation of sustainable development.

However, when dealing with complex systems meaningful global definitions are not always possible or useful. The Brundtland (1987, p. 8) commission's definition of sustainable development as behaviour that "meets the needs of the present without compromising the ability of future generations to meet their own needs" was left purposefully vague to allow various shareholders to work toward common ground. Others maintain that the resulting controversy over the definition of sustainable development has created a unique and constructive dialogue (Dale, 2001), and the precision of the concept has evolved considerably since the definition first popularised by the Brundtland report. The outcome of this dialogue has produced a generic, rather than a specific definition for sustainable development. It is a process of reconciliation of three imperatives. These are the ecological imperative to live within global biophysical carrying capacity and to maintain biodiversity, the social imperative to ensure the development of democratic systems of governance that can effectively propagate and sustain the values that people wish to live by, and the economic imperative to ensure that basic needs are met worldwide (Dale, 2001; Robinson and Tinker, 1997). This definition, however, remains general enough to allow for sustainable development to be interpreted differently in specific socio-geographic situations and to be sufficiently responsive in the face of unpredictable change and uncertainty. It also responds to the dynamic interplay between the imperatives, reflecting the complexity of modern human society.

Sustainable development literacy builds upon a progression of environmental and ecological literacies. The principal departure from these fields is the conception of the interrelationship between human and natural systems. The basic premise of sustainable development is that human and natural systems are dynamically interdependent and cannot be considered in isolation in order to resolve critical issues. Human societies and ecological systems are so interconnected that they are co-adaptive, reacting to each other and to previous interactions and reactions in a network of feedbacks. Jickling (2000) argues that the sustainability approach "blurs the very distinctions required to thoughtfully evaluate an issue". However, proponents of sustainable development counter that a lack of clear distinctions and boundaries is inherent in complex problems that must be embraced in order to establish a process of reconciliation. Our approach to sustainable development education must be complex, transdisciplinary, and broad (Jucker, 2001). As with many complex systems, distinctions cannot be made without excluding necessary aspects of an issue.

Sustainable development's links to the science of complexity cannot be ignored, yet have as yet not been fully explored (Rammel, 2003).

As sustainable development education aims to leave students with the ability to apply knowledge in a variety of unpredictable situations, practical problem-based learning is one of its requirements (Jucker, 2001; Johnson, 1999). Traditionally, students have lacked opportunity to put SD into practice (Steinemann, 2003), but this is a necessity if students are to be able to jointly create solutions (Wals and Jickling, 2002). There is also evidence that community based research can benefit both the student and the community involved, and helps to develop the ability to deal with the complexity of sustainable development issues (Keen and Baldwin, 2004). Furthermore, hands-on experience with sustainable development education at work can be incorporated into the course design itself; Jucker (2001) advises us to "practice what we preach", and redesigning the infrastructure of courses can be a good step (Steinemann, 2003). The case study at the end of this paper suggests a few ways that sustainable development can be incorporated into course structure and procedure.

Sustainable development education does not intend to instruct wildlife managers or ecologists on the influence of water quality on aquatic organisms, two examples of the traditional application of environmental and ecological sciences. These two disciplines are fact and tool oriented: they attempt to answer questions such as what level of toxicity is acceptable or how much habitat is necessary to sustain a population? Despite their invaluable application in certain circumstances they break down in others, particularly when confronted with problems that cross traditional disciplines, involve multiple stakeholders, and occur on multiple scales. The issues driven by the interaction of human society and ecosystems are particularly poorly suited to disciplinary analysis; critical sustainability issues such as climate change, consumption patterns and the vicious cycles of poverty, environmental degradation and their interlinkages have no simple answers.

These issues have been underrepresented by traditional environmental education (Huckle, 1999; Gough and Scott, 1999); sustainable development education attempts to fill this gap. The environmental and ecological disciplines are an integral component of the sustainable development approach to resolving such complex problems; but they alone will be unsuccessful, as they must be considered along with social, economic and political control systems that are ultimately the source of these problems. As each of these problems is unique, the study of general processes must override the study of fact bundles or "cookie cutter" approaches. Process-based learning, if properly implemented, leaves the learner prepared for the unexpected problems inevitable within a complex system. "Sustainable development has to support an adaptive and flexible process towards inevitable changes in environmental as well as in socio-economic systems" (Rammel, 2003).

Sustainable development has also been criticized as overly value-based. Jickling argues "sustainability and sustainable development are normative terms and placing them as desired outcomes of education is more reminiscent of indoctrination" (Jickling, 2000, p. 1). It is entirely appropriate to question the validity of a set of values as the basis of any educational program. However, sustainable development education's inherent flexibility allows it to accommodate differing and shifting value systems. Traditional disciplinary problems are typically bounded, and are either independent of the problem solver's value systems or they are grounded in a single value system. The

transdisciplinary nature of sustainable development requires that sustainable development education includes techniques to reach consensus among varying value systems, albeit not always successfully. Gains can be made toward the three imperatives of sustainable development even when the actors involved are not appreciative of all of the associated values although values articulation is one of its basic skills. As an example, sustainable development has in many cases been embraced by business leaders, although they differ markedly in terms of a shallow or deep appreciation of its fundamentals (Hawken *et al.*, 1999). Natural capitalists argue, for example, that the economy is only a few percent as efficient as the laws of physics permit (Hawken *et al.*, 1999), allowing companies to follow "no regrets" policies in which only financially positive sustainable development initiatives are initiated (Hawken, 1993). The goal of sustainable development education is to explore the reconciliation of critical ecological, social and economic imperatives, and these imperatives need not be seen as completely ideological.

The above definition of sustainable development arose to reflect a set of values widely accepted among scholars across a wide diversity of disciplines. Students are encouraged to critically reflect on competing definitions of sustainable development and the values that underlie them, and tailor the generic definition to achieve concrete goals in their unique situation given the constraints of institutional history, existing frameworks, and structural and financial limitations. Sustainable development must be seen as a process, not a goal; it is a constantly moving target whose boundary domains evolve as the dynamics between the three imperatives shift.

Literacy in the field requires education for a set of critical skills which will be discussed below. Therefore, the debate centred upon whether or not we should teach value based curriculum is diversionary; instead, we should discuss which particular skills will be most necessary to address the problems future generations will likely need to address, with a contextual appreciation of differing ideologies and values. Thus, sustainable development problems require broad, dynamic approaches that identify competing and often conflicting interests in order to establish processes of reconciliation. The understanding of this complex dynamic interaction is fundamental to sustainable development literacy.

There is an argument that the field is ineffective at addressing contentious environmental issues because it lacks the conceptual tools, the simplicity, and is "incapable of imposing sanctions on industry or government" (Jickling, 2000, p. 5). Indeed, sustainable development education alone does not contain the conceptual tools to reconcile complex problems. Its practitioners lean heavily on other disciplines, in particular environmental and ecological sciences. Rather than a conceptual tool, sustainable development acts as a point of unification, building the conceptual capacity to work through an interdisciplinary approach. Unification is a critically important component to knowledge. Sustainable development literacy requires understanding of complex systems, an interdisciplinary approach to its theory and a transdisciplinary approach to its practical implementation.

Defining literacy

To achieve literacy in a skill or subject one must master a set of learning objectives that varies depending on the nature of the subject under study. As will be argued below, in the case of sustainable development education in which the systems under study are

complex, changing, and locally diverse, these learning objectives are processed based in addition to facts based. Freire (2000) expanded upon the common definition of literacy in a relevant manner, describing literacy as "an active phenomenon, deeply linked to personal and cultural identity. Its power lies not in a received ability to read and write, but rather in an individual's capacity to put those skills to work in shaping the course of his or her own life". Sustainable development addresses global macro-problems that are intertwined with human activity systems, with these global macro-problems impacting multiple scales, most particularly the local. To achieve sustainable development literacy is to master the ability to understand these problems as global phenomenon but also to engage these problems at the local level amid changing and unpredictable circumstances.

In more traditional discipline-based fields literacy is typically measured through proficiency in a set of critical skills. In the case of sustainable development literacy, some authors argue that sustainable development does not concern itself with generating critical knowledge, but rather with changing values and lifestyles, dissemination of knowledge and informing people (Orellana and Fauteux, 1998). However, as all knowledge is grounded in paradigmatic thinking, sustainable development education is not a program focused on changing values, but rather one of values articulation, making them explicit, and developing the ability to place problems and issues in diverse contextual appreciations. The ability to solve a problem is a better measure of literacy than mastery of individual skills.

The reconciliation of three imperatives to develop integrated solutions at scales that range from community to global cannot be accomplished through the application of traditional skills alone. For example, sustainable development education must include as a goal the ability to work with actors with disparate value systems, and the ability to find meaningful compromises when various stakeholders do not have compatible goals. The particulars of these diverse viewpoints, which can include sustainable development educators, local stakeholders with their own local knowledge base, and outside experts and actors, create a very different set of challenges than is found in other areas of environmental education.

Sustainable development education and complex adaptive systems

Complex adaptive systems theory and thinking plays a key role in developing sustainable development literacy. Though there is no definitive definition of complex adaptive systems (Rescher, 1998), in general they are composed of interconnected components, the interaction of components and their relation with the environment. The nature of such a system cannot be understood by just analysing components (Cilliers, 1998). They have certain properties, such as feedback loops and dynamic interactions. Complex systems are open systems far from thermodynamic equilibrium and are organized such that each element is ignorant of the system as a whole and responds only to local information. Complex systems are also non-homogenous (Cilliers, 1998). In a much briefer summary, Waldrop (1992) says that the two defining properties of complex systems are that they have spontaneous self-organization and they are adaptive.

Both human social systems and ecological systems are complex adaptive systems (Reeves, 1999; Gunderson and Holling, 2002). Bar-Yam (1997) refers to human civilization as a super organism, an evolving and growing complex system, similar in

scale to the biosphere. Human societies, however, are located within the biosphere, and have reached a scale at which they are now evolving co-adaptively with the biosphere. Sustainable development education must, therefore, be rooted in the science of complexity to a larger degree than environmental education. In addition to a grounding in complexity and systems theory, interdisciplinary research and processes are critical domains of sustainable development education.

Sustainable development education must focus on a processed based as well as a traditional facts based knowledge in order to account for the inherently unpredictable self-organization and emergence present within ecological and social systems. Any facts based knowledge set can be rendered irrelevant by either gradual or sudden unexpected change. Sustainable development literacy must focus on the teaching of thought processes capable of understanding and developing novel responses to dynamically evolving and changing situations. Warburton (2003) argues that to achieve these goals, educators must provide a wide range of conceptual and material content, illustrate interconnections and interdependence, and stress dynamic rather than fixed structures and processes.

The roots of sustainable development literacy

Sustainable development literacy derives from a progression of disciplinary thought from both the natural and social sciences. Environmental education entered mainstream thought in the 1970s largely with the support of the United Nations (1972). The objectives for environmental education focused on the following elements: awareness, the acquisition of knowledge about the environment and its problems, the development of attitudes, values and behaviours that respect the environment, the acquisition of problem-solving skills, the development of capabilities to assess the situation, and individual and collective participation in the implementation of solutions to environmental problems.

Early environmental education presented the environment as a set of problems to be solved and prevented (Orellana and Fauteux, 1998). These deficits were partially addressed in the field of ecology, which shifted from a problem-solving focus to a systems approach stressing connectivity and relationships between organisms and communities (Capra, 1996). Ecology has continued to evolve towards a complex systems view based upon interaction and change (Gunderson and Holling, 2002). Central to this change is the awareness of network structure of living systems, nested systems, continuous cycles of energy and resource exchange, flows of energy and matter, development and co-evolution, and dynamic balance. Ecological literacy is still limited by the separation of natural and anthropogenic systems; reconciliation of this division is central to sustainable development education.

The epistemology of sustainable development literacy derives from environmental and ecological literacies with the addition of an emphasis on the interrelationship between human and natural systems (Gough, 2002). Norgaard (1994) expanded this perspective by describing human and natural systems as co-evolutionary. In fact, many experts argue that ecological theories should be re-conceptualised in the light of evidence of the impacts of human activity systems on the bio-geophysical properties of the natural world (Dale, 2001). By viewing human activity systems existing within a global ecological network, the need to theorize on the meaning of limits and scale emerges. This is the core of sustainable development, based upon the ecological limits

described by Meadows' (1972) controversial report to the Club of Rome. Their central concern was for a set of global macro-problems based on overpopulation in a world with finite resources; the lack of a resolution, they argue, will result in a "rather sudden and uncontrollable decline in both population and industrial capacity" (Meadows, 1972). While the predictions of "Limits to Growth" did not come to pass largely because the models failed to take account of complex feedback loops (Cole, 1973), therefore, the production of useful knowledge (Robinson, 1993) is what sustainable development education must address.

Sustainable development education encourages learners to develop problem definitions from several perspectives, and most critically, from interdisciplinary and transdisciplinary critiques and perspectives. Moreover, Rassool (1999) highlights the importance of "multi-literacies" and adequate levels of communicative competence in facilitating effective participation in the democratic process. The concept of multi-literacies introduces the idea that our civil societies have to become knowledgeable and literate of the general approaches to interdisciplinary problems. As well, a fundamental part of sustainable development literacy focuses on the ability to implement generated solution sets. Sustainable development is not a theoretical pursuit, but by its nature is rooted in praxis.

Attaining sustainable development literacy
Achieving sustainable development literacy begins with an exploration of the general definition of sustainable development and its three spheres; the economic, the ecological, and the social. Sustainable development literacy includes the more traditional environmental and ecology, and if these literacies are absent some familiarity with them will be needed as a first step in sustainable development education. In addition, one must acquire knowledge of interdisciplinary and transdisciplinary research methods, including both natural and social science methodology; multiple perspective taking and making; contextual appreciation and analysis, on multiple scales of interaction; and multiple complex systems perspectives that encompasses both the parts and the whole in dynamic interactions. The required skills can be broken down into facts based and process-based skills (Table I).

Key to the utilization of the above skills is adaptability. The basic requirement of sustainable development literacy is "adaptive flexibility, meaning the ability to

Facts-based skills	Processed-based skills
Systems theory	Systems thinking
Related disciplinary based knowledge pertaining to the ecological, social and economic imperatives	Interdisciplinary and transdisciplinary research methods
Natural and social science research methodologies	Perspectives taking and perspectives making
Action research	Contextual appreciation and analysis
Governance	Barriers analysis
	Backcasting and scenario building
	Multi-stakeholder processes
	Values articulation

Table I.
Sustainable development
literacy skills

address changing conditions through a process of continuous adaptive learning and the possibility to initiate new development trajectories" (Rammel, 2003, p. 397).

Barriers to sustainable development literacy
One of the biggest barriers to new literacies arises as "school curricula are organized into subjects that are defined by existing literacies, and prioritised by policy-makers on the basis of needs identified in relation to existing institutional structures, both organizational and cultural" (Gough, 2002, p. 8). Thus the study of institutional structures is essential to sustainable development education as it is impossible to explore new ways of thinking if people are not willing to understand and challenge the old ways (Schwab, 1978).

However, interdisciplinary learning does not come easily to those rooted in traditional disciplines. There is a tendency for practitioners to retreat back to a single discipline, thus failing to capture the holistic nature of problems and their solutions. Interdisciplinary activities tend to be seen as secondary to discipline-based approaches (Warburton, 2003).

Case study: Royal Roads University
In order to, as Jucker (2001) recommends, "practice what we preach", both the primary and secondary author have attempted to incorporate sustainable development principles into a selection of courses. Firstly, the three courses discussed below incorporate a sustainable infrastructure into their delivery. They are paperless courses; all readings are available online, class discussion takes place online or in-person, and assignments are handed in using electronic drop-boxes. The paperless format has proven popular with the students. The content of these courses is designed to embrace the hands-on problem-based learning required of sustainable development education, as well as the transdisciplinary approach needed to familiarize students with the complexities of sustainable development. These courses include an undergraduate business course in sustainable development (ES 322), an undergraduate course in environmental management (BE 319) and a graduate level course in research methods (MEM 550). Royal Roads University offers a distributed learning model where learners come together for intensive three-week residencies, followed by online courses; the latter two courses include such residencies, though the sustainable development course is taught entirely online in on-going session throughout the program, embracing Jucker's (2001) opinion that education for sustainability should be the transdisciplinary core of all education. The students are organized into learning cohorts and thus the very structure of the course offers extensive work in team settings, where process-based learning in interdisciplinary thinking and research can occur. During the sustainable development course, teams are given problems in sustainable development modelled on real world examples and must combine their knowledge with research during online team discussions. These sessions have proven very successful in encouraging students to work together and combine their knowledge in novel ways.

Transdisciplinarity is a key element of these courses and our programs in general; the Masters degree in environmental management offers both an MA and an MSc and these students are mixed in the same residence cohort, though they take different distance courses. Thus there are opportunities for linkages between the natural and

social sciences unavailable in a more traditional program. Fien (2002) believes that a variety of paradigms must be pursued in order to further sustainable development education, and to encourage this in the our students, the graduate course in research methodology offers an overview of both natural and social science methodologies. After the students have gone through the fact-based part of the curriculum, they are then given five research journal articles that they have to critique in their respective teams. Each of the articles has been selected from both the social and natural sciences and contains a "flaw" in the methodology that the student must identify. Part of the process-based learning imbedded throughout this critique is that at the end of the course students realize that their particular learning style influences what they regard as good research; students with lateral thinking tend to prefer journal articles written in the narrative style, whereas science students tend to be biased towards less descriptive and more data oriented research. We hope that exposure to a variety of learning styles will encourage them to venture outside their usual methods of learning.

Conclusion

Sustainable development education draws upon many disciplines, including environmental education, but is a discreet field because of its unique focus on complex systems theory; its grounding in interdisciplinary research and processes, and its applied research methods. Though many aspects of environmental education, specifically ecology, also draw heavily upon complexity, sustainable development education's focus on the interaction between social and ecological systems requires a much deeper understanding of both complexity and interdisciplinary thought. Exposing students to problem-based applied learning helps to develop this understanding as they struggle to use their knowledge in novel ways, a skill they will need in their further involvement with sustainable development issues.

The historical vagueness of the definition of sustainable development has led some authors to argue that sustainable development education is not a meaningful undertaking, but we argue that the general nature of sustainable development as a concept contributes to its epistemology, in particular, its process-based skills. The general idea of three imperatives of sustainable development, the ecological, the social, and the economic, provide a framework for study of concrete applications. Sustainable development literacy requires a complementary understanding of elements of environmental literacy, but more generally requires an understanding of interdisciplinarity and requires the acquisition of process-based tools capable of managing unexpected change. Sustainable development requires a break with traditional thinking and the reductive analysis of isolated, static systems (Rammel, 2003).

For sustainable development issues such as global climate change, facts are typically uncertain, values in dispute, stakes high, and decisions urgent (Dale, 2001). The "sound science" that is frequently invoked as the requirement for rational policy decisions is often impossible to achieve, or the costs of obtaining the data are prohibitive. The traditional distinction between "hard", objective scientific facts and "soft", subjective value judgments is often blurred by political objectives (Funtowicz and Ravetz, 1999). These difficulties require a very high level of sustainable development literacy to overcome.

Sustainable development literacy involves human attempts at creating meaning of self, culture, nature and artifacts, and their dynamic interaction as a result of human agency.

One must gain both a set of skills and the ability to implement those skills in dynamically changing and complex environments.

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