A new teaching tool in education for sustainable development: ontology-based knowledge networks for environmental training

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Abstract

This paper presents a prototype model for the design and development of environmental training materials, where both the multimedia objects used in training scenarios and the knowledge built into them are captured and fully reusable. Knowledge found in the logic, the structure and the ways of use of environmental literacy is represented as a knowledge network (a collection of educational scenarios), based on an ontology. A prototype environmental pollution ontology and three self-contained sample educational scenarios have been developed. The training approach helps students to understand the contemporary global environmental issues, how they are linked and interrelated and to consider the differing views of these issues, before reaching a decision or judgment.
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1. Introduction

Sustainability is a fluid and emergent concept that has attracted considerable discussion and criticism. However, internationally it has become the principal aim of environmental policy and for many environmental managers it has become an appropriate vision of the future. Various models of sustainability can be found in the literature but those that follow a three component or a multiple capital framework typically include elements relating to equity, empowerment, social cohesion and participation. One aspect of participation relevant to sustainability is public involvement in resource and environmental management. Public involvement is of fundamental importance because it is consistent with the principles of participatory democracy, improves planning and decision making, helps resolve conflicts and makes difficult political decisions more acceptable. If current patterns of resource use are unacceptable, and if sustainability is an appropriate vision of the future, by what means can society move from the present towards the vision? A detailed and comprehensive response to this question may be quite difficult and complex, but a reasonable survey of the alternatives would likely include environmental education and learning [1]. In other words, major ecological restoration will not be undertaken unless human society approves the goals and objectives of it and, in addition, has sufficient esteem for the restored ecosystems to protect their integrity. Linking ecological restoration to sustainable use of the planet seems a promising way to foster society's interest in and acknowledgment of human dependence on natural systems. An increase in environmental and ecological literacy is essential to achieving this end, as is an awareness of the goals and conditions of sustainability [2]. Although few dispute the need for behavioural changes leading to more effective mitigation of environmental problems, popularization of the term "sustainable development" and speculation about its role in education continue to be problematic for many educators.

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As a result, a number of experts claim that it is inappropriate to plan and implement academic curricula without adequate conceptualization of central concepts. In this case, ''sustainable development'' seems imprecise. Likewise, ''sustainable development'' has become, for many, a vague slogan, a bold platitude, susceptible to manipulation and deception. For some it is logically inconsistent. Others are concerned that efforts to implement sustainable development will obscure understanding of the economic, political, philosophical and epistemological roots of environmental issues, and adequate examinations of social alternatives [3]. This raises questions about the efficiency of traditional educational processes with regards to implementation of sustainable development.

In this context, this paper proposes a new teaching tool in education for sustainable development. Specifically, it examines the combination of a reusable ontology (made of concepts and their relations) that captures domain-specific knowledge, with reusable multimedia objects (MMOs) constructed specifically for teaching environmental literacy, in order to form a knowledge network (combination of educational scenarios).

All digitized educational aids for environmental training developed with the existing technology are essentially collections of multimedia files. These multimedia files are (a) grouped, (b) indexed and (c) combined in order to support various educational scenarios.

a. The grouping of these multimedia files follows a hierarchical structure organized in units and sub-units, etc. like the chapters of a book. So the user can select a unit or sub-unit and then the system guides the user to the multimedia that explains it.
b. Alternatively the user can use the index or the search feature, search for one or more words, locate the relevant units and when selecting them he is guided to the specific multimedia explaining them.
c. The multimedia can also be combined with the use of hyperlinks. Hyperlinks allow the user, while browsing the contents of a specific node (e.g. web-page), to move to another node or multimedia unit and when finished to return to the starting node.

But all this grouping, indexing and combining simply restructures the educational materials without representing the knowledge itself that is hidden within the material and that must be decoded by the trainee him/herself.

According to Sowa [4], perception is the process of building a working model that represents and interprets sensory inputs, a mosaic of percepts, into a more abstract part (conceptual graph). A conceptual graph is made of concepts that are composed of the simplest possible self-contained entities, and the relations between them. Therefore, when a trainee is asked to understand the training material accompanying a training process, the act of utilizing the material can be modeled as a two stage process: (i) the analysis process, where the material is broken down into concepts and (ii) the synthesis process, where concepts are linked to other concepts found in the training materials at hand and other related materials

that the trainee has already analyzed, in order to form more complex structures or conceptual graphs. Therefore, meaning is not discovered but constructed and training materials have meaning only in relation to other materials that are interconnected to each other as codes and systems in the culture and in the minds of the trainees.

The proposed methodology is designed to represent the knowledge found interspersed within the educational material for environmental training in the form of knowledge networks (collections of educational scenarios serving specific educational needs) that simulate the approach of analysis and synthesis of knowledge discussed. This makes it easier to be decoded and comprehended by the trainee.

Each knowledge network consists of various educational scenarios. The building blocks of these knowledge networks are domain-specific (for environmental training) ontologies. The ontology captures all domain-specific knowledge in the form of concepts (the simplest possible self-contained entities), instances of concepts and the relations between them. Educational scenarios combine the concepts, instances and relations found in the ontology with supportive multimedia (text, image, video, animation, etc.), thus combining the knowledge built into the ontology with the collections of multimedia objects (MMOs) currently used for environmental training.

In this context, this paper examines the combination of a reusable ontology that captures domain-specific knowledge, with reusable MMOs constructed specifically for teaching environmental literacy in order to form knowledge networks that can help trainees understand (i) which are the building blocks of an environmental issue, (ii) how they relate with each other and (iii) how they can be used in order to analyze specific environmental problems. For the needs of this research, an upper environmental ontology was defined and three educational scenarios were built; the associated lower ontology concepts and relations were defined to support them, with the tools developed by the CULTOS[2] project. The developed educational scenarios were based on Ryan's nine narrative structures [5].

2. Environmental literacy teaching in sustainable development

As is well known, sustainable development is economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs [6,7]. Critical to consistent progress towards sustainable development is the advancement and application of appropriate technologies and management strategies across socio-economic sectors throughout the world. These refer to strategies or production changes that benefit the environment even though that is not their primary intent. All of these advances and innovations are important for achieving economic growth while preserving and protecting the natural environment. This approach relies on a number of independent factors among them, research, physical capital investment, financial

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