SUPPORTING LEARNING IN ENVIRONMENTAL ENGINEERING: INTERACTIVE WATER TREATMENT PROCESSES

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Abstract

Teaching and learning environments which use multimedia based resources have the potential to greatly improve the effectiveness and efficiency of learning by engaging students at a deeper level than may otherwise be possible. The presentation media and teaching methods work together to enrich the experience, providing the students with a greater opportunity to explore their own 'mental pictures', develop understanding and revise it as necessary. This is particularly so in situations where 'real world' phenomena and processes are being taught. Using such a multimedia package in teaching pollution control processes is novel. This paper reports on the successful development of a multimedia package dealing with several pollution control processes and its evaluation. Teaching the design concepts for these processes in a conventional classroom setting is challenging because students have difficulty in visualising the techniques and processes involved. This difficulty is compounded by the fact that many of the processes occur naturally over longer time periods and so cannot be easily be integrated into normal teaching environments. The software package incorporates several different media modes including text, animation, and simulation. A pilot evaluation of this package using third year engineering students indicated that it supported the development of greater insight and understanding of the complex treatment processes being taught.

Keywords

water treatment, simulation, environmental engineering, multimedia, student centred learning

Introduction

The utilisation of interactive, multimedia based tools and delivery mechanisms in teaching and learning environments is becoming an important aspect of the implementation of a more innovative approach to teaching in all disciplines including engineering. The value of the delivery mechanism in the learning process has long been under debated. While many side with Kozma (1994), accepting that the delivery vehicle is as important as the teaching methods, there are many who are convinced by Clark's (1994) argument that media will never influence learning. The authors of this paper however take the view along with Reiser (1994) and others, that the two must work together and that in fact, it is the delivery vehicle which in many cases facilitates the use of particular methods.

One of the key elements of a multimedia learning environment is its ability to provide the learner with control, which is the essential feature of a "democratic environment" for learning. Current interactive multimedia technologies can represent ideas in almost any mediated form, and provided we can generate a comprehensible metaphor for organising our functional options and the underlying knowledge structures, the student can roam through the resources, creating their own meanings and understandings of the phenomena they encounter. (Corderoy, Wright, Harper & Hedberg, 1996).

It is suggested by Jonassen (1988) that learning environments that utilise interactive multimedia have a number of attributes that are essential to efficiency and effectiveness. In particular, interactive multimedia provides opportunities for higher levels of engagement, improves representation of information so that there is a 'closer fit' with the formats the current generation of learners are familiar and comfortable with, and facilitates contextualised feedback. Such highly interactive environments allow the learner to learn at his/her own pace at a time and place that is most convenient and 'supportive', and to be 'selective' in the overall experience he/she has while navigating the learning environment. Recent research into learning processes (Jonassen & Reeves, 1995) focuses on the students and the 'cognitive tools' such as simulations, they have at their disposal as 'intellectual partners' in the learning process.

It is the purpose of this paper to outline an interactive multimedia teaching resource based on the constructivist paradigm (Reeves, 1993; Jonassen, 1991; Winn, 1993) and present some early results from the evaluations carried out.

Simulating "Real World" Processes

The processes described in this multimedia software package demand some imagination to understand the principles and the continuous and often extended nature of their operation. Also, there are several components of the processes that are difficult to explain or demonstrate without the aid of 'real world' experience or a substituted laboratory simulation. The functions and processes of these components can be easily demonstrated using pictures, hyper linked text, simulation and modelling techniques to provide risk free environments in which the user may 'experiment at leisure' to come to terms with the difficult concepts involved and thus gain a deeper understanding of the systems at work.

In general, simulations

> ...greatly enrich the 'quality' of the problem solving process for the user by providing unhindered access to act and become immersed in a 'real' situated process, manipulating the various causal parameters and testing hypotheses without a 'real' consequence or risk and in a time frame which is convenient and manageable for them and enabling the learner to ground their cognitive understanding in their action in a situation. (Laurillard, 1996).

At the same time, well structured simulations which are based in open ended models provide users with much richer learning experiences by "allowing the monitoring of all parameters while the simulation is running, with the aim of exploring the relationships between them." (Corderoy, Harper & Hedberg, 1993).

Multimedia in Engineering

A multimedia approach can be a very useful tool for teaching fundamental concepts in Engineering. For example, in the case of sedimentation process, the process depends on the settlement of particles under gravity. Under discrete settling conditions, the settling of particles is given by Stokes' equation (Metcalf & Eddy Inc., 1991):

$$v_s = \frac{g(\rho_p-\rho)d_p^2}{18\mu} \quad (1)$$

where,
v_s = vertical settling velocity of the particles
g = gravitational acceleration due to gravity
d_p = particle size
ρ_p = density of particles
ρ = density of water
μ = dynamic viscosity of water

Equation (1) gives the vertical velocity of the particle. However, in a continuously operating sedimentation tank, the particles are also transported in the horizontal direction as well. The horizontal velocity of the particle can be given by:

$$v_h = \frac{Q}{wh} \quad (2)$$

where,
Q = inflow rate in to the tank
w = width of the tank perpendicular to flow
h = depth of the tank

The particle removal depends on the magnitude of vertical and horizontal velocities and without some way of 'visualising' this process (such as a simulation in which the user has control of the variables), students may not develop a full understanding of the process. This package offers students the opportunity to test their mental models of a number of complex processes involved in water treatment. Further information about the package and its design can be found in Dharmappa, Corderoy and Hagare, (2000).

Evaluation

A pilot study was conducted to evaluate the package using 30 students from the third-year BE (Civil & Environmental Engineering) course at University of Wollongong, Australia. A questionnaire consisting of 2 parts was prepared and it was administered to all the students. Part A this questionnaire dealt with the design and functionality issues of the software while Part B explored the students impressions of the impact using the software had on their overall learning.

General Findings

Although the sample was small, this simple formative survey provides valuable starting points in terms of design and educational considerations in the development of such teaching resources. The students indicated that the animations and simulations included in the package were very useful to them in testing their 'mental models' and developing understanding. The students particularly liked the level of interactivity included in the simulations of processes that they would not otherwise have the opportunity to observe. In terms of general design issues, most felt that navigation through the package was relatively easy and the instructions for using it were clear and accurate. In terms of the student's perception of its impact on their learning experience, comments made by a number of students indicated that its main impact was that simulations let them 'explore' the processes, providing them with a "better understanding of what makes the process work". There was also a perception that they were better able to contribute to tutorials having used the package.

Conclusion

The software package that is the focus of this paper is designed to give students some idea of the actual operation and design of various water pollution control processes. It also explains and consolidates their understanding of the operating principles and performance of the processes, by providing them with the opportunity to engage and interact within a rich, student-centred learning environment whilst constructing their knowledge. A limited pilot study using third-year undergraduate engineering students indicated that the multimedia software is a useful tool to support learning for students in Civil & Environmental Engineering and has provided impetus to further develop this resource. An extensive program of evaluation using a larger cohort is scheduled for the later stages of 2001.

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