

# Computer Graphics in Environmental Education

Oscar Anson\*  
Univeristy of Zaragoza  
Spain

Adolfo Munoz†  
Univeristy of Zaragoza  
Spain

Belen Masia‡  
Univeristy of Zaragoza  
Spain

Jorge Lopez-Moreno‡  
Univeristy of Zaragoza  
Spain

Diego Gutierrez‡  
Univeristy of Zaragoza  
Spain

Jorge Jimenez§  
Univeristy of Zaragoza  
Spain



Figure 1: Computer Graphics applied to wastewater environmental education: Through the combination of 2D and 3D techniques in a step-by-step virtual walkthrough, the user has an enhanced learning experience, visualizing the *ins and outs* of different water treatment processes.

## Abstract

Computer Graphics has become an important field where other scientific disciplines found suitable methods to express and visualize their theoretical concepts. By using these graphical tools, educators can provide research-oriented, interdisciplinary collaborative experiences that engage students from varying scientific fields.

In this paper we present ED-WAVE [edw ], a learning tool created under the Asia-Link Programme, dedicated to the development of regional and multilateral networking between higher education institutions in European Union (EU) Member States and South-East Asia and China. ED-WAVE is an innovative product of high interdisciplinary action providing theoretical information, worked out examples, case study database and case base reasoning in the field of wastewater environmental treatment. Computer Graphics played an important role by exposing the target groups to real-life applications through virtual industrial and municipal environments, enhancing the learning experience. The importance of visual depiction in the context of the project, led us to include Computer Graphics contents in the curriculum development, as well as the use of the tool itself. The target groups involved students in undergraduate and graduate level, educators and young professionals working in water and related industries.

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\*e-mail: oanson@unizar.es

†e-mail: adolfo@unizar.es

‡e-mail: jlm@unizar.es

§e-mail: jim@unizar.es

¶e-mail: belenmasia@gmail.es

||e-mail: diegog@unizar.es

## 1 Introduction

In the last decade sustainable development has become a key concept in most aspects of life, of which education is an integral part. Therefore, environmental education has turned into an important part of many academic curricula [Crofton 2000]. Naturally the field of engineering and science ought to play a pioneer role in offering renewed courses in this field, as engineers are responsible for safeguarding the environment health through it, by the means of design, construction, production and inspection.

In practically every aspect of engineering and science, computer-based tools are being developed to aid students and professionals in learning through modeling, visualization, simulation and interaction. The Internet has been utilized as the ideal medium to create platforms for students to use for its wide availability but also computer graphics based software are developed in order to enhance the teaching process. The students in engineering degrees usually have difficulties when it comes to understand some concepts, even the basic ones. And the key is when they express their frustration — “I don’t see it”.

Here is where computer graphics comes into play, expressing in a visual way these concepts and trying to help the engineering students train the necessary skills to carry out creative design based on abstract thinking process [Ursyn and Sung 2007]. But the users of these educational tools usually should be helped in order to understand the methods of presentation of specific multimedia technology, where text, sound, pictures, video, 3D and interaction can be combined into a whole [Lewis et al. 2006] [Franco et al. 2006].

ED-WAVE, the project addressed in this paper, fills the gap between

theory and real-life practices in wastewater treatment education. In this sense, computer graphics played a main role, bringing theory to life through combined 2D and 3D animations and graphics. The visual depiction was so crucial that basic techniques in computer graphics and visualization were included in several courses in institutions as part of curriculum development. In this way, target groups can also understand how “visual theory” was depicted, and thus, continue with the knowledge transfer chain.

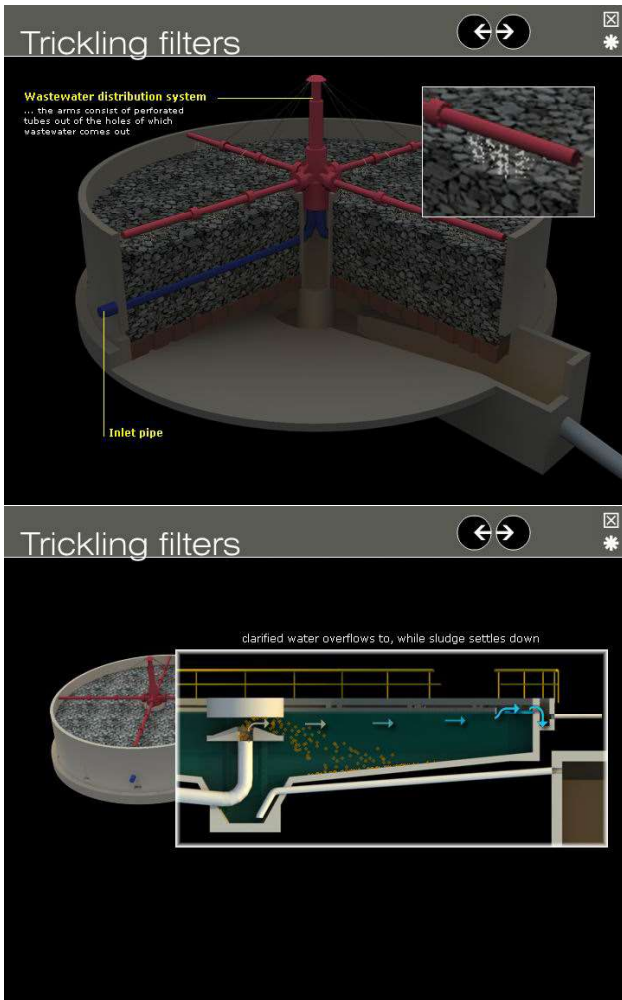


Figure 2: Two screenshots of the Trickling Filters animation. Cross-sections along with animation of certain elements help to understand the water flow and internal operation of the process.

## 2 Implementation of the ED-WAVE project

The project was divided into six different tasks, which are briefly described as follows:

- **Study of water status.** This study involved a review of existing water use status and practices in both domestic and industrial sectors. The study focused on different aspects such as water consumption patterns, cost of supply water, water sources and discharge routes, wastewater treatment practices, cost of effluent treatment and discharge, quality profile of wa-

ter and wastewater, growth in demand trends, existing legislation on wastewater reclamation and reuse and wastewater reclamation and reuse applications including reuse of domestic wastewater for agricultural purposes.

- **Evaluation of treatment technologies.** This second activity involved review of potential technological interventions leading to improved water efficiency through conservation, reclamation and reuse. The processes covered broadly fall into both High-tech (appropriate for developed countries or large scale industries) and Low-tech (appropriate for developing countries or rural communities) categories.
- **Process modelling.** This activity covered the simulation of impacts of specific technology interventions on water use; modelling the effect of a particular technology and its operating conditions on parameters such as throughput, quality characteristics and energy use; optimisation of flowsheet, location and flow of recycle streams and operation economics; simulation of options for water reuse to create closed loops in the selected processes; determination of process sensitivities and predicting the effect of intervention on a whole system and development of operating strategies.
- **Visualization.** A key aspect in this educational project was the visualization of all the processes, to ensure a correct understanding. This includes visualising the raw data from previous activities, creating virtual scenarios and allowing the user to see the impact of specific technology interventions. Another important educational feature was to allow the user to select a combination of operating parameters for any given process and then observe the simulated outcome.
- **Integration of course contents.** Due to the crucial importance of the visualization task in the design of the ED-WAVE project, adapted computer graphics theory was included in developed curricula, as well as all the technical and theoretical wastewater treatment content. The following specific courses were created:
  - Technologies for efficient water use.
  - Modelling and visualisation of water treatment processes.
  - Efficient water and energy use in pulp and paper industry.
  - Computer graphics and new technologies in environment education.
- **Training.** Training workshops were held in multiple locations. The training was aimed at professionals from educational and research institutions, environmental practitioners, technical service providers, potential end users from various industries and municipal bodies, local governments, environmental agencies and policy makers responsible for technical education and e-Learning.

## 3 The ED-WAVE tool

The education tool is a package of computer applications supplemented by data files, animations and demonstrations. The system consists of 4 modules: Reference Library (RL), Case study Manager (CM), Process Builder (PB) and Treatment Adviser (TA). The package can be divided to a theoretical part (RL, CM) and a practical part (PB, TA) and models included in the RL). The RL is a structured e-book with theoretical knowledge on wastewater unit operation as well as training examples; CM contains case studies

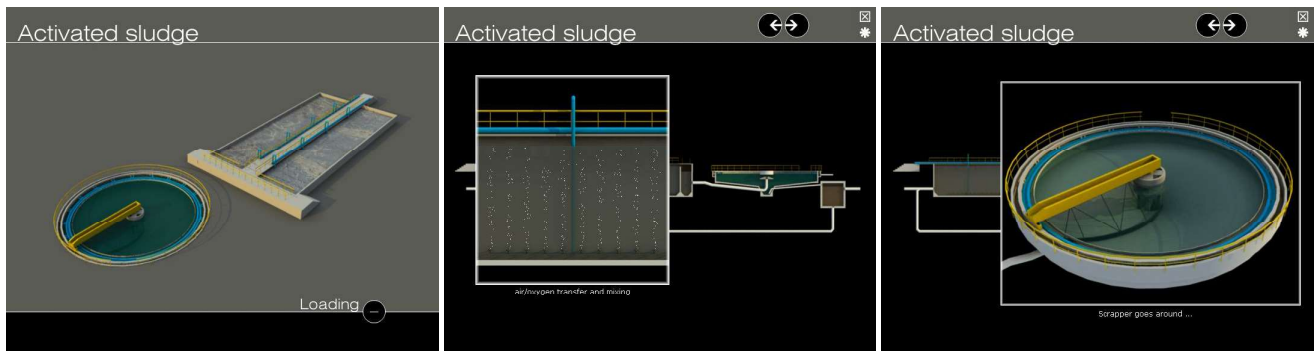


Figure 3: Three screenshots of the Activated Sludge animation.

from real life applications. PB serves to construct a full treatment sequence from basic unit operations presented as blocks and TA assists in problem solving exercises. In addition supplemental "glossary" section gives the user brief information about terminology encountered in the software. Thus the tools components support the complete training activity from presentation to problem solving and design of the units. All materials are presented instructed thematic ways and navigation is similar to the World Wide Web browsing. Novel techniques such as case base reasoning and stream set analysis are implemented in the components of the tool. The four tool modules consist in more detail as follows:

### 3.1 Reference Library (RL)

This module aims to assist the tutor in the formulation of his presentation of select technologies and of the formulation of coursework. It also aims to provide the user with an easy to use concise form of the traditional book- with text, pictures and problems- and to virtually walk the user through each technology. The RL is not a substitute for textbooks though. It provides concise information and technical details but urges the user to the use of further published work through references. The module provides the user with a comprehensive overview of 21 processes used for wastewater treatment.

Each process consists of several sections such as theoretical background, design parameters or examples, but is in the "view section", where the user can find a schematic representation of each technology, view 3D image(s) of each process and also view a full animation with explanatory text showing and describing each process. In all the cases 3D images were modelled and rendered from digital pictures and engineering drawings, from operating wastewater treatment plants. In animations, the user is taken in a virtual step by step walk through in each process. Pointers, labels and accompanying text, explain the main features of each technology during the animation show. The animation is split to frames and sub frames. The transition from one frame to the following is controlled by a "forward" button, so the user can regulate the pace of the demonstration. In all animations cross section views of unit operations allow the user to have an inside view, not visible in a real wastewater treatment plant visit and observe the phenomena taking place within. The importance of visual media in teaching and training cannot be overstressed. Students and young professionals who have a theoretical knowledge of technologies and processes have seldom had the opportunity to actually see such units in practice. Pilot plant units in laboratories and field visits offer contact with only a limited number of technologies, usually restricted to those applied locally. Moreover, since this is a Europe-Asia cooperation programme, even tutors and experienced professionals haven't had the chance to familiarise themselves with some of the technologies

presented. Fig. 1 to Fig. 4 illustrate select screenshots of the animation from several technologies.

### 3.2 Case Study Manager (CM)

This module contains a collection of past wastewater treatment situations based on design experience from real life situations which can be used to solve a new problem specified by the user. The case base of the CM includes a total of 70 case studies obtained from municipal and industrial wastewater treatment plants from both Asia and Europe.

The module serves the dual aim of first acquainting the user with real wastewater treatment practices in the selected sectors, familiarising oneself with parameters of concern and their range in the relevant industry and with the degree of achievement of treatment. The module allows the user to train based on real industry data and test one's own problem and scenario. For maximum involvement and training outcome, the user is allowed to set the weight of the input parameters himself under the instruction of the tutor for a select scenario.

### 3.3 Treatment Adviser (TA)

This module is activated when the user is not satisfied with the solution suggested by CM. Based on an analysis of parameters submitted by the user, the TA generates one or several possible treatment sequences which are then evaluated using data from the past applications of the technology.

The generated sequences are ranked according to evaluation values gained using data from the past applications of the technology. The user can browse on these sequences and save the selected treatment to be open then in the Process Builder as a constructed scheme.

### 3.4 Process Builder (PB)

This module can be used in place of the CM to create and view a valid treatment sequence. The module contains 24 icons (each icon representing one process) that can be dragged, dropped and connected to generate a valid treatment sequence. The module is based on a valid sequence matrix allowing the user to view when a treatment scheme is not feasible. The target of the module is that the user, after having familiarised oneself with the concept of the methods and with the practices used in the industry, or with the sequence proposed by the CM, creates one's own wastewater treatment plant, in the form of unit operations blocks. The system accepts treatment sequences by assessing whether two subsequent technologies can be applied or not. The matrix for the permission



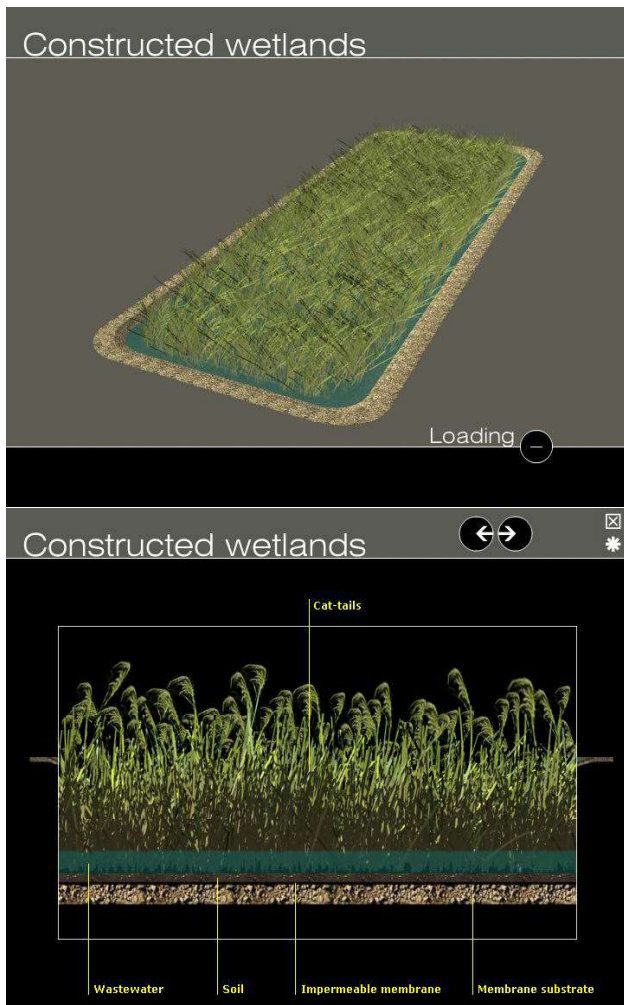


Figure 4: Top: Aerial view of the Constructed Wetlands treatment process. Bottom: A cross-section of the wetlands, showing the distribution of layers.

or the refusal of the sequence is based on technical feasibility only and not on other parameters such as land availability, cost, energy consumption etc. Two examples of both a valid and a non-valid sequence are showed in Fig. 5.

## 4 Conclusion

We have presented ED-WAVE, a learning tool applied in wastewater environmental curricula and return of a high interdisciplinary project. Computer Graphics played an important role along the whole project, providing full featured animations of several theoretical processes, combining 2D and 3D concepts in order to enhance the learning experience. The importance of this visual information was so crucial that several subjects on Computer Graphics, ranging from digital imaging and multimedia authoring to 2D and 3D animation and modelling techniques, were included in different courses of the developed curricula.

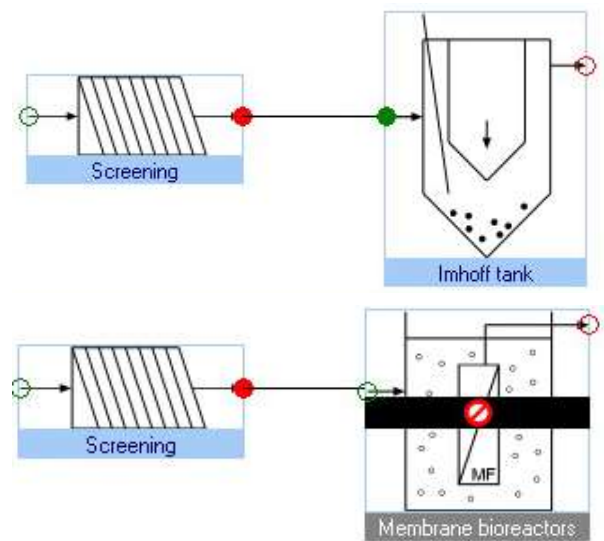


Figure 5: Two sample treatment sequences in the PB module, formed by two blocks. Top: A valid sequence composed by a screening unit and an Imhoff tank. Bottom: A non-valid sequence showing that a membrane bioreactor can not be placed after a screening unit.

## 5 Acknowledgements

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