The Interactivity in the New Engineering Education Tools

Fernando G. Martins* and Sebastião Feyo de Azevedo
Departamento de Engenharia. Química, Faculdade de Engenharia, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal

Abstract
This paper presents two web simulators to solve problems of numerical methods and process dynamics and control. The aim is to show how interactivity can enhance the utilization of the new information and communication technologies resources as learning/teaching tools.

Keywords: World Wide Web, interactivity, learning/teaching methods, numerical methods, process dynamics and control

Web sites: http://mn.fe.up.pt, http://www.fe.up.pt/~fgm/procdyncontrol/

1. Introduction
Engineering education learning concepts and learning tools have been changing drastically as a result of the overall revolution in the information and communications technologies. New information and communications technology resources, such as web sites, are reshaping educational institutions by providing new learning environments and new ways of teaching. Many web sites present new nice features such as interactive examples, animation, video, narrative and written texts, which indeed represent the basis for new learning/teaching methods.
In general, some people are still reluctant in using these types of tools. Some still see features and contents as of poor quality. It is time to change mentalities and to show that many advantages can be obtained if these methodologies are used in the correct mode.
The power of learning and teaching using these resources is mainly in interactivity. Several techniques are available that allow the user to interact with the resources, in this way influencing positively the quality of his own learning process of the courses being offered.
Students are more interested in the courses if they can complete on-line and on-time several tasks. From learning to evaluation interactive on-line materials and exercises can give to student more rapid feedback than when work is turned on to paper and the results and evaluation come back some (long) time after.

* Author to whom correspondence should be addressed : fgm@fe.up.pt

2. Word Wide Web based Simulators

This paper presents two web simulators that have been (keep being, as all web-based tools…) developed having in mind the concepts and directions just stated. Their main objectives are to solve problems through the Internet and using a web browser. They further serve to show how interactivity is important in the learning process.
The first web site was developed using VBScript and the aim is to solve problems of numerical methods. The second web site uses the Matlab Web Server to study problems of process dynamics and control.
The theory related with these tools is standard and covered by many textbooks, as it is the case of Chapra and Canale (1998), for Numerical Methods, and Seborg et al. (2003) for Process Dynamics and Control.

2.1 A WWW Numerical Simulator

The goal of this project was to provide the Internet with a site where lecturers and students can work together for better understanding the basis of numerical methods through interactive use of applications. For a long time classes on this subject have been emphasising underlying theory behind the methods and their algorithms, leading naturally to the programming of such methods in a range of computer languages like FORTRAN, Pascal, C, and BASIC. In this case students acquire practice on computer languages, but the task is very time consuming and limited in interactivity for the student that by the time of the exercise happens not to be yet fully familiarized with the programming languages. In many situations, the numerical methods and their application are just approached superficially, their capabilities remaining not fully explored and their flaws not fully understood.
Since these algorithms are available in many text books and in some websites as well, the idea of making them available for direct use and interaction in web based environments is naturally emerging rapidly.
Starting from these key concepts and exploring the recent capabilities of last generation browsers, the web site was brought to life, gathering the most common numerical methods taught in science and engineering courses.
During the early stages of the web site conception much more attention was paid to functionality, ease of use and interactivity with the user, relying documentation about methods and algorithms intentionally in a second plan. However, a brief description of each method can be also found in this site, leaving a more thoughtful discussion of these methods for the lecturers, adequate literature or even other educational websites on the subject.

Example - Root Finding of a Non-Linear Equation

This web site has available four methods for finding the roots of non-linear equations. When choosing a method for this type of problem, the user is offered an user-interface where textboxes appear by default filled with data of an illustrative example.
For Newton-Raphson's method the example and template provided are presented in Fig. 1.. It is considered the search of the roots of the non-linear equation -

$$\sin(x) - 0.5 = 0 \qquad (1)$$

with the initial guess 0, a target relative error of 0.00001 and a function target absolute error of 0.0001.
As seen, all that is required is to introduce the relevant information in the correct fields, which for this method further includes function derivative and the maximum number of iterations. For any other problem, users are requested to change the information accordingly

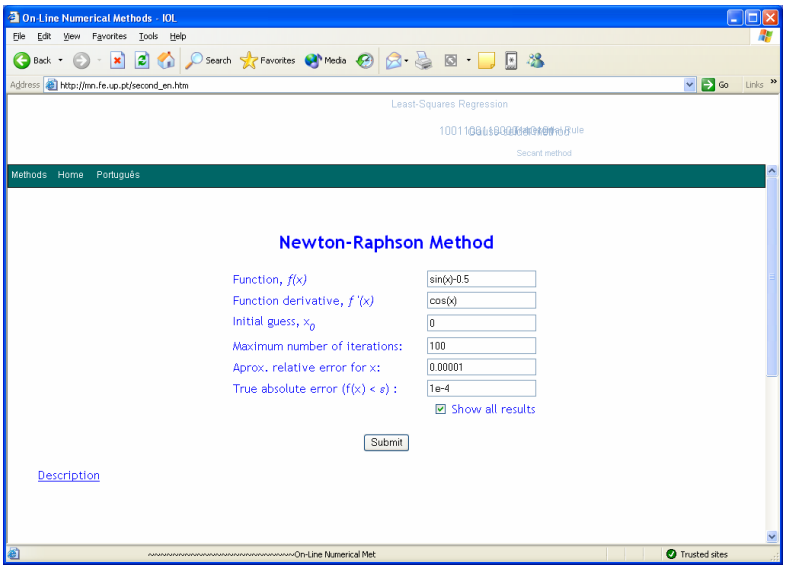
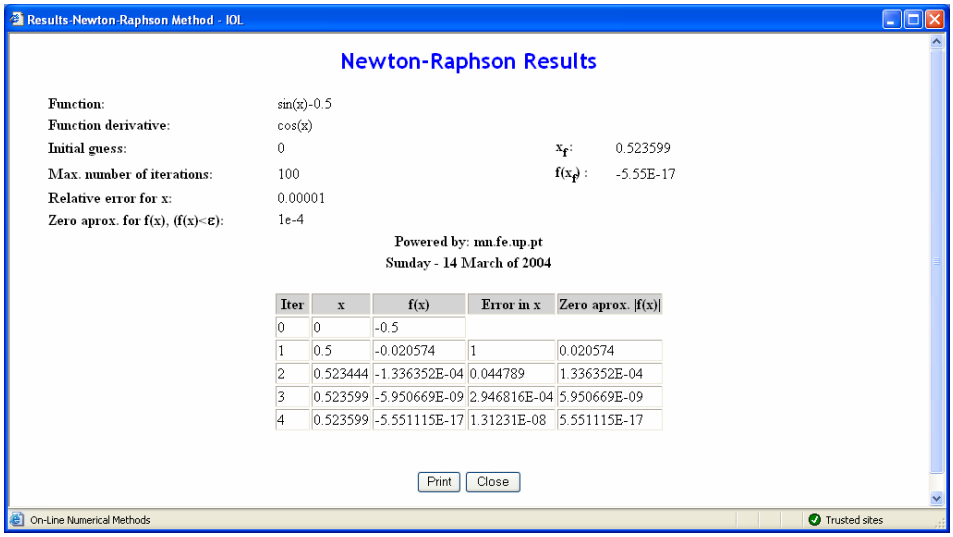


Figure 1 - Newton-Raphson method interface.

After a click on the **Submit** button, results appear in a new window (Figure 2), in an easily readable way, being possible to print or discard them or generate alternative solutions for robust analysis of the numerical solution.



Iter	x	f(x)	Error in x	Zero aprox. |f(x)|
0	0	-0.5		
1	0.5	-0.020574	1	0.020574
2	0.523444	-1.336352E-04	0.044789	1.336352E-04
3	0.523599	-5.950669E-09	2.946816E-04	5.950669E-09
4	0.523599	-5.551115E-17	1.31231E-08	5.551115E-17

Figure 2 - Newton-Raphson results page.

2.2 Process Dynamics and Control

The objective of this web simulator is to use the functionalities of the Matlab Web Server and Matlab Control Toolbox to solve several problems of process dynamics and control. Through this site it is possible to study in an expedite way different basic aspects such as producing different system responses, sketching root locus diagrams, tuning PID controllers using Ziegler-Nichols controller settings based on continuous cycling method and analysing the feedback control system performance for set-point changes.

Example – Step Response for a Second Order System
Supposing a process with a transfer function given by:

$$G_p(s) = \frac{1}{4s^2 + s + 1} \tag{2}$$

through a very simple template, presented in Fig. 3, the user is requested to supply the relevant information for the basic system (parameters k, τ, ζ and θ in this case) and also to choose the type of dynamical analysis required (from a group of options).

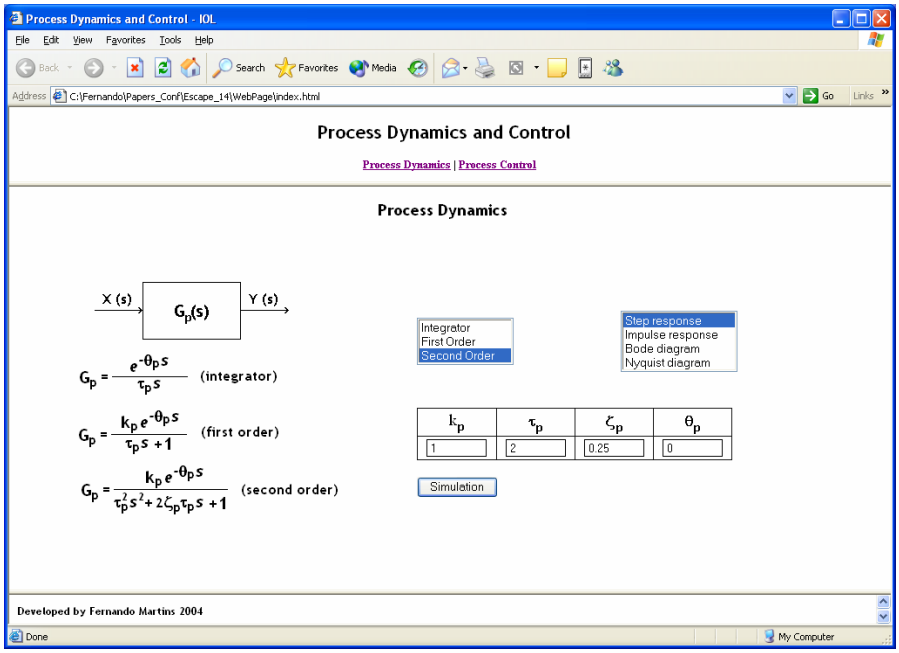


Figure 3 – Web page to introduce the transfer function parameters

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After a click on the **Simulation** button, the results appear on web page as depicted in Fig. 4.

A wide variety of case studies can be easily and quickly generated.
Furthermore, and now from the development point of view, the modular programming structure adopted ensures the rapid growth of the number and type of solutions made available to the users.

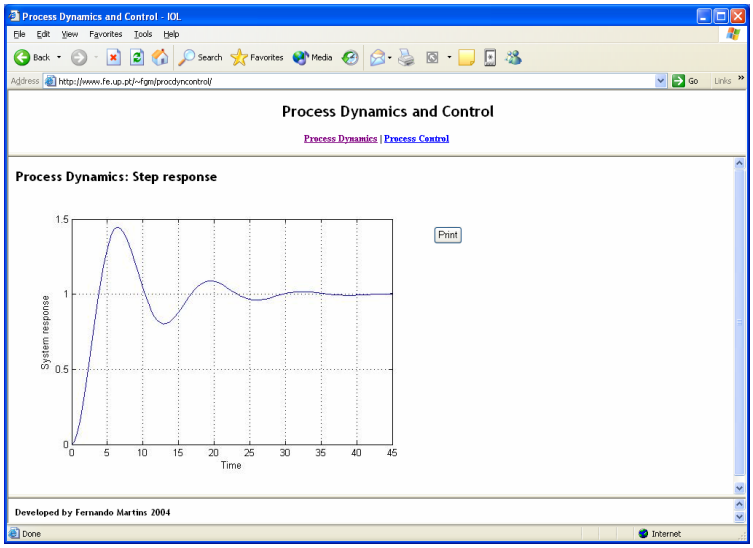

Figure 4 – System response for a unit step change in input X(s).

3. Conclusions

Through these two examples, developed using different resources, but with some standardization of interfacing, we illustrate the development of interactive educational tools, making use of available communications technology and means. This kind of products plays already a major role as complement or alternative to traditional learning/teaching methods and can be very effective in designing distance learning courses.

4. References

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Dale E. Seborg, Thomas F. Edgar and Duncan A. Mellicamp, 2003, Process Dynamics and Control, 2nd edition John Wiley & Sons, New York.