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Using the Web as part of the classroom in Numerical Analysis Courses

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Abstract

Virtual environments are highlighted as a good option to be used as part of the classes and to extend classes outside the classroom. The research group GIE at Facultad Regional San Nicolas from the Universidad Tecnológica Nacional of Argentina, has designed and published several websites of issues of different subjects. The use of these tools in the learning process allows students to become more active, autonomous and reflective. This fact generates adequate conditions for students to understand the basic ideas presented. The aim of this paper is to present the different sites designed for Numerical Analysis Courses and the impact they had on the subject during 2014.

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1. Introduction

The use of websites on teaching processes contributes to enhance and empower the teaching given in the physical classroom in many aspects. First, it increases the limits of the class in two dimensions, space and time: teaching and learning processes can occur outside the classroom and out of the scheduled time for the class. On the other side, the use of didactical resources represented by hypertextual and/or multimedia material lets the approach to the issue studied be enriched and, at the same time, obtain a better adaptation to the students’ different learning styles.

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The purpose of the use of websites in face classes is the creation of a space to facilitate and promote the meaningful learning in a more attractive and dynamic way. But it is necessary to be careful when taking into account the use of websites for learning.

As Robova (2013) points out, there are benefits and risks when students use Internet as a tool for learning. The key benefits of integrating websites in the classroom lie in: increasing the clarity of explanation and learning effectiveness, student motivation and proactive approach, individual approach to instruction and the possibility to test student knowledge and skills. Some of the risks of using available websites in mathematical classes are: possible mathematical errors, didactical deficiencies in the preparation of materials, time spent searching for quality and freely available websites, and language barrier for foreign websites.

Following Baki and Guveli (2008), the appropriate usage of web-based mathematics teaching material should include the offer of a consistent and structured approach to learning, the provision of a frequent positive feedback, and a variety of text and visual materials. Educational material prepared to be distributed by the web should include audio and action effects, and it should be used not only in education centers but also at home, at work, and wherever and whenever required.

For the exposed reasons, since 2010, the authors of this paper are working on the design of material available on the Web for the topics of Numerical Analysis studied at the Facultad Regional San Nicolás from the Universidad Tecnológica Nacional of Argentina. In this paper the developed websites are discussed, and an analysis of their use in 2014 is presented.

2. Numerical Analysis Websites

So far, the developed websites covering the issues of Numerical Analysis, published in Spanish, cover the topics:

- **Nonlinear Equations.** Iterative methods for solving this type of equations are presented: bisection method, Newton’s method, secant method, regula-falsi and fixed point iteration.
- **Linear Equations Systems.** Two different approaches are used to solve linear equations systems: direct methods, elimination and decomposition, and iterative methods.
- **Interpolation and Curves Fitting.** Interpolation, both by Lagrange polynomials and using splines, is discussed. Also, least squares approximations are presented.
- **Numerical Integration.** Newton Cotes formulas and Gaussian Quadrature are introduced.
- **Numerical Methods for ODEs.** The two kinds of problems involving ODEs are presented: initial value problems and boundary value problems. Explicit methods are discussed for the first group: Euler, Taylor and Runge-Kutta. For the second group, the finite difference method is introduced.
- **Numerical Approximation of PDEs.** Three classes of PDEs are introduced: elliptic, parabolic and hyperbolic, focusing in the Poisson equation, the diffusion equation and the wave equation, respectively, approximated with finite differences.
- **Finite Element Method 1D.** The weighted residual approach is used to obtain the matrix equations for linear and quadratic elements in one dimension. In particular, the Poisson equation is studied.

There is no restricted access to these sites, they can be retrieved from anywhere in the world from the site http://www.frsn.utn.edu.ar/gie, clicking the "Recursos" (Resources) button.

In general, all the sites designed as a complement to the current classes of the Numerical Analysis courses present the following sections:

- **Introduction,** where the reason to learn the issue is shown, by some introductory problems.
- **Basic Concepts,** where the corresponding theory is explained, using clear and simple language.
- **Interactive Applications,** where different tools are offered. These interfaces are presented with usage instructions and examples that allow students to understand certain concepts (Caligaris, Rodriguez & Laugero, 2013; 2014). Figure 1 shows two applications, translated into English for this paper. The first one, designed with Mathematica, allows choosing between linear, quadratic and cubic least square approximations, for a set of seven points. The second one, designed with SciLab for using the finite element method for the heat conduction...
problem in a rod, provides the alternative to discretize the spatial domain through linear and quadratic elements, and shows both approximations, individually or simultaneously, using the selected number of elements.

- **Exercises**, where solved exercises are displayed and a guide with exercises, contained in a PDF file that can be downloaded and printed, is presented.
- **Self-Assessment**, which offers a series of multiple choice questions, developed with eXe (exelearning.org). These questions offer a hint that can be used before answering. Each time an answer is selected a brief explanation is shown: green if the choice was correct or red otherwise. In this way, each answer has a feedback, stimulating the fact that the correct option has been selected or giving guidelines if an incorrect answer has been chosen.
- **Links of interest**, where interesting sites on related topics are listed. In this way, students can get other examples or tools.
- **Bibliography**, the books used to develop the material contained in the sites are presented here.

![Fig. 1. Interactive tools from different sites](image)

### 3. The use of the sites as part of the classroom

Evaluation is a process that should be associated to any project of development and teaching improvement. To carry out this task, it is necessary to apply some techniques of inquiry that probe about the factors that contribute to the improvement of the students’ learning process.

The websites developed for numerical analysis in the FRSN are used during the lectures and in practice classes, taking advantage of the available interactive tools. In order to evaluate the use of these sites, students completed an assessment poll by the end of the course. This survey was made up of two parts. The first one consisted of a series of closed questions, which were analyzed with a Likert scale (Hernandez Sampieri, Fernandez Collado & Baptista, 1998). In Table 1, the Likert scale is presented, showing the numerical value assigned to each option. Table 2 shows some of the relevant statements included in the first part. The average of the answers was used for the analysis. The second part consists of a series of open questions, asking for some students’ opinion.

<table>
<thead>
<tr>
<th>Table 1. Scale and numerical value.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
</tr>
<tr>
<td>Numerical value</td>
</tr>
</tbody>
</table>

| Table 2. Some statements in the questionnaire with the obtained averages. |
How often did you use the site?  
Do you believe that the information contained in the sites is enough for understanding the different topics?  
Do you think it is helpful to have solved exercises when performing the exercises?  
Do graphics contribute in understanding?  
Do the questions of the self-assessment allow a proper review of the learning?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often did you use the site?</td>
<td>1.74</td>
</tr>
<tr>
<td>Do you believe that the information contained in the sites is enough for</td>
<td>1.87</td>
</tr>
<tr>
<td>understanding the different topics?</td>
<td></td>
</tr>
<tr>
<td>Do you think it is helpful to have solved exercises when performing the</td>
<td>1.40</td>
</tr>
<tr>
<td>exercises?</td>
<td></td>
</tr>
<tr>
<td>Do graphics contribute in understanding?</td>
<td>1.53</td>
</tr>
<tr>
<td>Do the questions of the self-assessment allow a proper review of the</td>
<td>1.33</td>
</tr>
<tr>
<td>learning?</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 shows the number of students who considered that the interactive windows were "very helpful", "quite helpful", "of little help" or "of no help at all" in the understanding, deepening and consolidation of the concepts involved.

Figure 3 shows the frequency of use of some elements of the sites, particularly the basic concepts, the interactive windows, the exercises and the self-assessment.

From the data exposed in Fig. 2 and 3, it seems that the developed websites became useful for students’ learning. The tools offered are used as scaffolding to the apprenticeship, mainly the self-assessment questionnaire, which allows students to probe their comprehension of the issues studied.

The open questions that were included in the second part of the questionnaire, inquired about the place where they usually connect to Internet, the accessibility of the sites, their opinion about the way that information is presented, and the type of navigation used in the site. They were also asked for an assessment of the websites as a supplementary instance for the study of numerical analysis. Besides, it was required to indicate what contributed most and what aspects were not useful, and if they would suggest modifications so as to improve the impact they have on the learning of students who use these sites.

In the question about connectivity, most students answered that they surfed the Internet from home. This fact shows that consider the use of websites as part of the study material gives flexibility to the moments that students study and to the places where they study.

With regards to the sites’ accessibility, students expressed that it is rather good, and that not only the way information is presented but also the type of navigation are suitable to accomplish a correct comprehension of the developed issues.

Here are some of the answers provided by students, about the sites as a complementary tool in numerical analysis courses.

- "It seems a good idea to incorporate websites where students can enter as we are familiar with computers and find it easy and attractive to learn through a website"
- "Really, the websites seem excellent to me. They are developed in a very good way that shows just the information that you need, in a clear way. I love them!"
- "The sites are an adequate complement to have a more dynamic vision of numerical analysis issues. They are really useful because the applications make possible to view different methods altogether"
• "It is a very important additional source of information for students that don’t have much time for seeking bibliography at the FRSN because of work"

• "The use of websites is really good because for many of us the use of a computer as a tool for studying is very attractive"

A considerable percentage of students pointed out that the most relevant elements of the websites are interactive windows, solved exercises and self-assessment, and the fact that they didn’t use the bibliography and links of interest sections.

With regards to possible changes on the sites, students suggested the possibility of getting a pdf file with the basic concepts so as to make easier to obtain printed copies of theoretical concepts.

4. Conclusion

Nowadays, almost all of the issues that make up the Numerical Analysis courses have a corresponding website. These websites not only allow increasing the motivation for the study of Numerical Analysis by manipulating multimedia and/or interactive materials, but have also become an important teaching tool.

While each of the sites was designed so as to contribute to the improvement of teaching and learning, they are flexible resources: they can be modified according to the needs detected in students or requirements that arise on the development of the classes.

As it could be seen in the obtained results, none of the indices for the various items of the performed questionnaire exceeds the value 2. This means that the materials available on the sites contributed quite a bit or a great deal in the students’ learning process. This fact was also reasserted by the opinion expressed by students about websites as a complementary tool in the learning process. In Numerical Analysis courses at the Facultad Regional San Nicolás, websites have virtually substituted printed material.

References


