MathMedia - Mathematics and Multimedia New Technologies for Teaching and Learning Basic Engineering Mathematical Courses

Geovan Tavares; Helio Lopes; Marcos Craizer;
Sinesio Pesco; Iaci Malta; Luis Nonato
{geovan, helio, craizer, sinesio, malta, nonato}@mat.puc-rio.br

Department of Mathematics
http://www.mat.puc-rio.br
Pontifical Catholic University, Rio de Janeiro, Brazil
http://www.puc-rio.br

Abstract

In this paper we describe an undergoing project at the MathMedia Laboratory (http://matmidia.mat.puc-rio.br), Department of Mathematics, Catholic University, Rio de Janeiro, Brazil to build an integrated multimedia environment for teaching and learning the basic calculus (and linear algebra) courses for the sciences and engineering.

Introduction

At the end of the millennium we still face an old dilemma: How to integrate, at the learning/teaching level, Mathematics, the Sciences and Engineering?

53 years ago Polya devised several steps in which we have to go through to understand and solve a mathematical problem [7]; moreover he placed ***classroom*** and ***heuristics*** at the forefront of the learning/teaching process in mathematics. Kline, 25 years ago, stirred us up with his insightful ideas about not only learning and teaching of mathematics [5,6] but also the role of mathematics in society as whole.

Even though new technological and cognitive science methods are available, still teaching and learning of mathematics is delivered, in most places, the old fashioned way: blackboard, chalk, pencil and paper.

Changes have been slow, but at a constant pace, and in several places, students and teachers, have benefited either from technology and/or cognitive methods.

The Mathematics Education Reform (mathedreform) in the US, sometimes taken by heated debates [4] , has started a change on the teaching and learning of calculus and of mathematics in general.

In fact, the advent of softwares like Mathematica (http://www.wolfram.com), Maple (http://www.maplesoft. com), Derive (http://www. derive.com), started at several places along the world a changing in the way mathematics is taught and learned.

Three examples of distinct approaches to the Calculus Reform are the Calculus Consortium based at Harvard (http://www.math. harvard.edu:80/~calculus/), the RUMEC group in Mathematics and Education based at Georgia State University (http://rumec.cs.gsu.edu/) and Calculus&Mathematica Group at University of Illinois at Urbana-Champaign and the Ohio State University.

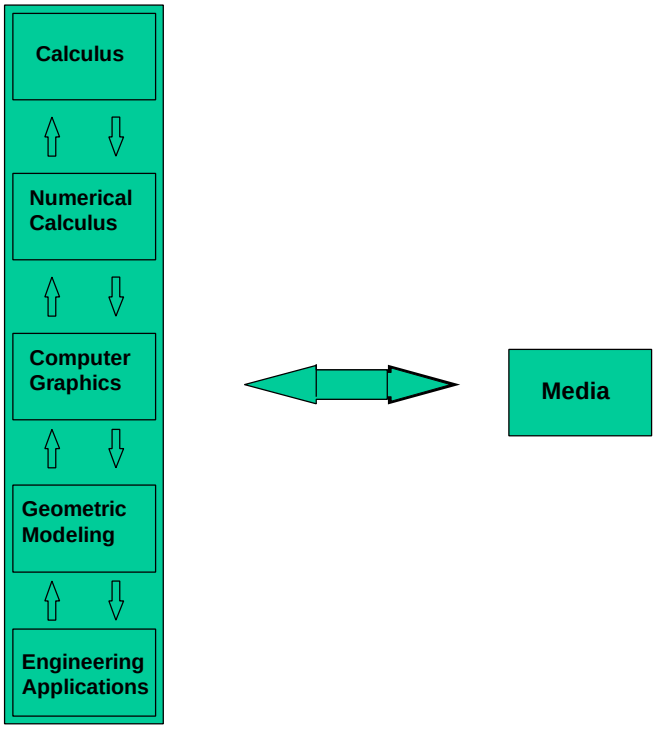
In Brazil, the MathMedia Group (http:// www.matmidia.mat.puc-rio.br/) at the Catholic University of Rio de Janeiro and the Mathematics of Computation Group-MatWeb Project-(http://www. mat.pucrs.br/matweb/) at the Catholic University of Rio Grande do Sul have started projects to use technology as a tool for teaching/learning basic courses in mathematics at the university level. There are several other individual initiatives on the same direction at some Federal Universities around the country.

The MathMedia Project for Calculus

At the core of the project is the viewpoint that an integrated computational environment for teaching/learning mathematics should focus on concepts and simulation thus avoiding programming as much as possible at an early stage of the calculus student life cycle.

The two main parts of the project are writing textbooks and building the corresponding software.

The following diagram illustrates the way in which the software part of the project was designed.



The calculus programs are the traditional ones taught at most brazilian universities: calculus in one and several variables and differential equations with the addition of some topics, e.g. splines curves and surfaces, and finite differences equations as the starting point for differential equations.

The introductory numerical calculus are finite differences, numerical integrals, Newton's method, numerical methods for differential equations.

For the computer graphics layer we focus on interactivity (including animation), display jointly with numerical analisys, geometric modeling techniques and engineering applications.

The understanding of surfaces, parametric and implicit, has been, traditionally very limited. With geometric modeling and computer graphics techniques it is possible to explore and simulate with these surfaces. Splines and Implicit surfaces are included in this computational environment.

The engineering applications will include beams, shells, and their deformation among other topics.

The software is object-oriented and implemented in C++ and OpenGL at this is stage of the project; next we will design an implementation in Java.

For Media we mean CDRoms, the Web and textbooks.

Learning and Teaching Considerations

With this environment there are several considerations we have to make. The emphasis on teaching and learning calculus should shift from the proof-oriented courses to mathematical concepts and results combined with numerical analysis, computer graphics, geometric modeling and engineering applications through a multimedia environment.

Most calculus courses have been using computer graphics in a rather static way, the so-called *illustration*. What we are proposing is, among other things, to shift to *interactive illustration* [Bell, Doppelt, Hughes, 1996] to build computational environment where group work should complement individual work in a very significant way, and where engineering applications should be integrated to ordinary mathematics course.

References

[1] Brooks, D. W. - Web-Teaching: A Guide to Designing Interactive Teaching for the World Wide Web. Plenum Press, NY, 1997.

[2] J. Beall, A. Doppelt, J. F. Hughes - Developing an Interactive Illustration: Using Java and the Web to Make it Worthwhile. Preprint, Computer Sciences, Brown University, 1997.

[3] Fosner, R. - OpenGL Programming for Windows 95 and Windows NT. Addison Wesley Delopers Press, 1996.

[4] Jackson, A. -The Math Wars Parts I and II. Notices Amer. Math. Soc. , June/July and August 1997. http:// www.ams.org/notices/

[5] Kline, M. - Why the John Can't Add: The Failure of the New Mathematics. St. Martin's Press, 1973.

[6] Kline, M. - Why the Professor Can't Teach: Mathematics and the Dillema of University Education. St. Martin's Press, 1977.

[7] G. Polya - How to Solve it: A New Aspect of Mathematical Method. Princeton University Press, 1945.

[8] Stroustrup, B. - The C++ Programming Language. Addison Wesley, 1995.

The MathMedia Project is funded by FINEP, CAPES, CNPq, FAPERJ and PUC-Rio.