# *Xmath*: eLEARNING PROJECT IN THE EU MINERVA ACTION

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**Abstract** The project Xmath will demonstrate and evaluate the use of XML (MathML), on-line calculations and FLASH animations in mathematical courses on the Internet. Mathematics has a negative development at universities and colleges: the number of students in mathematical courses and the number passing the exams are "dangerous low". To meet this challenge the teaching of mathematics has to undergo an innovative process where new technology is important. The pedagogical evaluation of using the web in mathematical education both locally and at distance will be focused.

## 1 Introduction

The use of the web in the education of mathematics and science has up to now suffered from lack of standards to represent the special symbols and operators used in these fields. These symbols and operators have been either GIF images on page or they have to be viewed/evaluated by using special software packages installed locally. The mathematical content of these symbols and operators is often absent.

The main idea of the Xmath project [1] is to use brand new technology to overcome these difficulties and to incorporate advanced on-line calculations and animations in web-based course materials. The use of the XML standard MathML [2], which is intended to facilitate the use and re-use of mathematical and scientific content on the Web, is critical important. MathML can be used to encode both the presentation of mathematical notation for high quality visual display, and mathematical content where the semantics plays a key role.

## 2 Objectives and plans

The participating institutions have for many years been using mathematical software and multimedia documents in their teaching of mathematics. Governmental authorities have plans for the integration of new technology in education. Mathematics has been especially focused for some years. In many european countries both the number of students in mathematical courses (university) and the number passing the examination have reached a "dangerous" low level and industry and schools are complaining.

To meet this challenge the pedagogics and methods of communicating particularly higher mathematics will have to undergo an innovative process where new technology is

important. The connection between mathematical pedagogics and ICT has to some extent been underestimated. The improvement of understanding mathematics by using interactive and

personalized documents in a non-linear and event-driven manner could turn bad trends for mathematics. And the problems associated with girls and mathematics also have to be emphasized through the selection of applications.

Mathematics and ICT is in its very birth. One very important factor of this shortcoming has been the difficulties with distributing mathematics on the Internet. Until now this has in fact not been possible due to technological problems and the lack of standards. Mathematics on the web has NOT been mathematics but images.

The development of the new standard for describing documents on the Internet, XML (MathML), has now made it possible to include “real mathematics” on a web page and to introduce this brand-new technology in connection with mathematical education. MathML will convert "frozen images" to "live materials", the main difference between ordinary books and multimedia documents. “Real mathematics” will in this case mean that that equations and mathematical expressions may be understood by mathematical software packages for evaluation. A “frozen” gif-image may not. Introducing MathML will be an important strategic factor in the development and innovation of mathematical and scientific education on the Internet and represents a "quantum step" in rendering mathematics in a web browser.

MathML consists of a number of XML tags that can be used to mark up an equation in terms of its presentation and also its semantics. MathML attempts to capture something of the meaning behind equations rather than concentrating entirely on how they are going to be formatted out on the screen. This is on the basis that mathematical equations are meaningful to many applications without regard as to how they are rendered aurally or visually.

MathML is a low-level format for describing mathematics as a basis for machine-to-machine communication. MathML is not intended for editing by hand, but is for handling by specialized authoring tools such as equation editors, or for export to and from other math packages. This simple example of MathML gives you an idea of how it works. The equation in question is: $\mathbf{x^2 + 4x + 4 = 0}$ using semantic tags (content) and presentation tags:

**Content markup**

```
<apply>
      <plus/>
      <apply>
         <power/>
         <ci>x</ci>
         <cn>2</cn>
      </apply>
      <apply>
         <times/>
         <cn>4</cn>
         <ci>x</ci>
      </apply>
     <cn>4</cn>
  </apply>
```

**Presentation markup**

```
<mrow>
  <mrow>
       <msup> <mi>x</mi>
<mn>2</mn> </msup>
<mo>+</mo>
          <mrow>
            <mn>4</mn>
<mo>&InvisibleTimes;</mo>
            <mi>x</mi>
          </mrow>
    <mo>+</mo>
    <mn>4</mn>
  </mrow>
    <mo>=</mo>
    <mn>0</mn>
```

</mrow>

The objectives of Xmath is first of all to design a framework making it possible to use MathML in mathematical education on the Internet and making it possible to evaluate the pedagogical advantages of web-based education in mathematics. One of the key elements of web-based pedagogics generally is connected to the communication process student-student and student-teacher over distance (synchronous and asynchronous). The framework then has to include a management system and communication resources understanding MathML documents. One of the participants has developed the very first system for e-communication using mathematical symbols, operators and shapes (ScientificTalk). The framework also has to include software making it possible to generate MathML code automatically and to evaluate (calculate) content markup. The framework will have the following components:

- Blackboard, educational portal and Xmath management system [4]
  - Announcements, User information and Staff information
  - Course- and other relevant documents, Assignments
  - Communication with Digital drop box, Discussion board, Virtual rooms, Roster and Group pages
  - Virtual room (specific group) has options for on-line chat with session archives, questions and answers panel, participant information panel, slides panel, incoming questions panel, whiteboard for drawing and access to external URL's
  - Tracking system for personal- and course-activity (statistics and assessment results)
- webMathematica, on-line calculations [5]
  - Adds interactive calculations and visualization to a web site by integrating *Mathematica* with the latest web server technology.
  - Uses familiar web interface elements such as buttons, drop-down lists and text fields
  - Uses client technologies such as a JavaScript and JavaApplets
  - Including templates to give your web site a professional appearance
  - Adding a special Mathlet command to HTML also using FORMS, typical (extract):

```
<FORM ACTION="CollTerm" METHOD="POST"><div><font size="5"
color="#004080"> Expression:</font> <INPUT TYPE="TEXT"
```

```
NAME="expr" ALIGN="LEFT" SIZE="25" value="<%Mathlet MSPValue[
$$expr,"x+3x"] %>">> <br><br><INPUT TYPE="image"
NAME="btnsubmit" img src="Design/compute.gif" width="83" height="22"
border="0" VALUE="Compute"><br><br> <img src="Design/results.gif"
width="306" height="17"> <%Mathlet MSPBlock[{$$expr},
Together[$$expr]]%> </div></FORM></div>
```

- ScientificTalk, on-line mathematical chat [6]
  - Enter letters and numbers from the keyboard (similarly to a web chat room or to the Talk Unix command) by writing shared text
  - To select mathematics signs/symbols from an Equation Editor to write down, display and share equations, formulae, etc.
  - To plot analytical functions (besides discussing)
- IBM techexplorer [7]
  - Plug-in for Navigator and Internet Explorer, IE 5.5 XML behavior, and and ActiveX control for applications like Microsoft PowerPoint and Word. Techexplorer enables the display of TeX, LaTeX and MathML documents and the publishing of interactive scientific material on the Web
  - Version 3.1 includes full support for MathML 2.0, augmented LaTeX display, new ways to enliven documents via scripting/programming, a web equation editor and Mathematica connectivity
- Mathematica from Wolfram Research [8]
  - Generating/understanding MathML markup code
  - Calculating engine in connection with webMathematica

Mathematical education has traditionally two main goals: to train students in logical and abstract thinking and to give students an ability to use mathematical knowledge in fields other than mathematics itself. Achieving, in particular, the last goal will require a high level of what we call understanding and the understanding of understanding will be important [9]. We need to let the student feel importance in a wider context than the upcoming examination. The use of interactive and event-driven documents will enhance understanding and allow an explorative and personal way of working. These documents are efficient and direct and may combine different kinds of hypermedia. MathML content markup, on-line calculations and animated graphics (Flash) [10] will make this possible in mathematical education.

This is expected to enhance mathematical pedagogics on the Internet and will stimulate activity, independence and collaboration, and may also prevent sharp distinctions between girls and boys using ICT. In this way the teacher will be more of an instructor rather than a professor.

Representing mathematics using MathML content markup will make it possible to include semantics that means that mathematical expressions may be evaluated in site (by accessing a calculating server) or by pasting the expression into mathematical software installed locally. The student may then "play" with the expressions rather than only looking at them. The history of evaluation may be accessed by the student and it will be possible to draw graphs and to make simplifications. Special focus will be put on the communication process that is one of the main differences between ordinary teaching and distance learning.

The project will be based on central theories within mathematical didactics where communication is important in addition to process-oriented teaching and learning by exploration and discovering. On this background we will encourage student-active ways of learning where students are working in small groups getting instructions using the Internet.

We hope that the use of MathML documents in mail and chat will enhance communication. The use of MathML will strongly support one of the most important parameters here: the exactness and unambiguousness of the communication. Innovative pedagogical methods in connection with virtual rooms for group activities will be evaluated by using small groups to look for advantages connected to the group size. Due to the software ScientificTalk [6] developed by one of the participants, the very first communication software using mathematical symbols, operators, drawings and graphs, such an exactness and unambiguousness will be possible in mathematics for the first time. Important differences between netbased pedagogics and traditionally pedagogics lies in this communication process and in the ability to monitor the students' work. You then have to use a management system that may be called a vertical portal for distance learning. The framework described earlier includes such a portal.

To demonstrate the use of MathML and to be able to evaluate the pedagogical impact of using it, a pilot course in university mathematics then has to be developed using the framework. The students taking the pilot course then have to explain and apply:

- Basic number theory
- The definition and basic properties of rational functions, exponential functions, logarithmic functions and trigonometric functions
- Limits, continuity and differentiation of these functions
- Integration and basic methods of integration
- Series, in particular Taylorseries and approximate functions with Taylorpolynomials
- Solve simple differential equations and use them to simulate and make models of natural and social phenomena
- The use of on-line tools for teaching mathematics

It is emphasized to show how functions appear ”naturally” in the formulation of practical problems and how differential and integral calculus give us a tool for handling dynamic processes and mathematical models of different kinds.

The evaluation of the pilot course will be divided into two parts: evaluation of on-line learning locally (with professors available) and evaluation of on-line learning at distance where the communication between the students and the professors mainly will be electronic with 2-3 meetings all together. In the first case this means that mainly the course material as such be will be evaluated. The use of interactive multimedia books with on-line calculating tools and animations (could be with synchronized sound) will be focused. In the second case the pedagogics of distance education will be evaluated especially (small groups arrangement). The tools for evaluation will be on-line questionnaires, Blackboard options (student statistics and assessments), final exam and of course the general impression of the instructor (professor).

## 3 Important instructions and suggestions

Since MathML is not generally well known because this is a brand-new technology or even more important the lack of browsers to render it, the project partners have to take responsibility in connection with dissemination of both MathML itself and the envisaged outputs of the project. It is expected that the use and interest for MatmML will be increasing both in education and publishing. The project group will have as an objective to create and maintain a web site [1] concerning the use of MathML and webMathematica in education.

The Xmath web-site includes a description of the project as such, links to sites in connection with the framework and important tools, on-line demo tools, news groups (Xmath community and open discussion groups) and a restricted area for project participants. Project results will be presented at conferences and it is the intention to give seminars on project subjects.

A suggestion here given by the coordinator of the Xmath project could be to incorporate project subjects as a part of future versions of the Applimat conference. This means to have dedicated sessions about MathML, on-line calculations, Flash animations and upcoming technologies and the pedagogical effect of using them.

## 4 Conclusions

Since the project is in its very beginning no conclusions about project subjects are available.

## 5 References


[1] http://xmath.org
[2] http://www.w3.org/Math/
[3] http://xmath.org/XmathPart.htm
[4] http://kurs.hibu.no/
[5] http://www.wolfram.com/products/webmathematica
[6] http://www4mail.org/cgi-bin/sci-talk/sci-talk.cgi
[7] http://www-4.ibm.com/software/network/techexplorer/
[8] http://www.wolfram.com/
[9] Bringslid,O (1999) Multimedia Books in the Mathematical Education of

Engineers, European Journal of Engineering Education Vol. 24, No. 2 1999
[10] http://www.macromedia.com/software/flash/contents.html

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