WEBALT ONLINE COURSES AND THE JEM THEMATIC NETWORK

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Introduction

The authors have been involved for many years in projects aiming at advancing the usage of new technologies in mathematics, like semantic markup, for enhancing electronic contents used in teaching. This paper discusses two of these projects, namely the WebALT project and the ongoing Joining Educational Mathematics Thematic Network, both sponsored by the European Commission.

The underlying conviction, common to these efforts, is that computers and the Internet have the potential to revolutionize, in a good sense, instruction. Mathematics instruction is a recognized key asset in our society and embracing technology in mathematics education is not only economically advantageous but also promotes better learning and understanding. While this belief is hardly disputed, it is also true that new technologies are seldom introduced in the classroom and those instructors who adopt novel ways of teaching are often seen with suspicion by the traditional colleagues, especially mathematicians.

In the final report, the National Mathematics Advisory Panel has observed the lack of studies that evaluate fairly the learning effects of new technologies and advocates for more research in this area. Nonetheless, it also concludes that certain tools, in particular systems for automated testing and assessment, can improve the performance of students' in specific areas of mathematics.

We have focused on interactive exercises and automated practice, testing, and assessment by developing a technology to deliver on-demand translations of the exercises in a number of languages and more recently, by creating a large collection of exercises.

Joining Educational Mathematics

Three are the stated goals of the JEM thematic network (1):
- to pool together the expertise required to produce best practice content for mathematics,
- to contribute to the coordination of content enrichment activities in the area of mathematics and to the maintenance of agreed standards
- to deliver powerful synoptic high-quality user information and support pages.

The expertise competences of the members of the JEM network range from a long standing contribution to the standardization of languages for the electronic communication of mathematics, like OpenMath (2), MathDox (3) and OMDOC (4), to the development of learning environments such as symbolic computation systems like WIRIS (5), assessment systems like STACK (6), and more recently wikis like the semantic wiki SWiM. Teaching long distance courses in mathematics is also a competence which is well represented within the JEM network, by large universities such as the Spanish UNED and UOC and the German FernUni Hagen, as well as that of more traditional academic teachers in front of a classroom.

The main activity of the network is the organization of meetings, special interest seminars and official JEM workshops twice a year. The workshops allow for all participants to share ideas and to update and coordinate the national efforts, hence they are the main way of promoting uptake of existing standards, or of project's results. The other major service of the network is the creation of a web portal[1] to gather the community with tools such as RSS feeds, blogging, wikis and a repository of learning resources, software and services descriptions and case studies that can be tagged and reviewed/scored by every registered member.

The JEM repository mixes the more traditional metadata-based approach, requiring users to register the resources by filling in a LOM metadata record, with Web 2.0 free tagging approach which permits the usage of a number of freely chosen tags, a so-called *folksonomy*, typically used in video and image sharing web sites. This collection of keywords describes the knowledge and interests of the JEM community as it evolves.

WebALT Project

Several among the partners of the JEM network have been cooperating before in transnational research activities and EU funded projects. One example is the Web Advanced Learning Technologies project, which was funded in 2005-2006 by the EU Commission within the eContent program with approximately 2.5 million € (4 million US$). The main aim of the project has been to combine the web technologies for representing mathematics electronically with computational linguistic tools to produce a system that would generate interactive mathematics exercises in the natural language desired by the user on demand.

The key observation is that mathematical content can be represented in an abstract form that is exact and amenable to machine processing and can be translated to the mathematical jargon in a specific language. The project produced a mathematical grammar library for the Grammatical Framework, GF, software to handle the abstract representation of the interactive exercises written in an extension of OpenMath, Additionally, WebALT has also developed multilingual software for editing, viewing and playing these multilingual exercises.

WebALT Online Courses

During the WebALT project interactive digital elearning materials were developed for several mathematics courses, such as Single Variable Calculus, Multivariate Calculus, Geometry, Abstract Algebra, and Mathematical Logic. Most complete and used in practice of these is the Single Variable Calculus course by Mika Seppälä who began developing slide pres-

[1] http://www.jem-thematic.net

entations of lectures to be delivered via online virtual learning environments long before the project started.

One of the novelties of the WebALT project has been to utilize web-based assessment systems to deliver automatically gradable homework and tests to students' computers. Automatic assessment is seen to be useful from the student's perspective since the system gives immediate feedback and in many cases complete stepwise solutions to the problems to help learning. Numerical and other parameters of a question are usually randomized so that each time student gets a different version of a similar type of a problem and this enables learning of the basic techniques and methods.

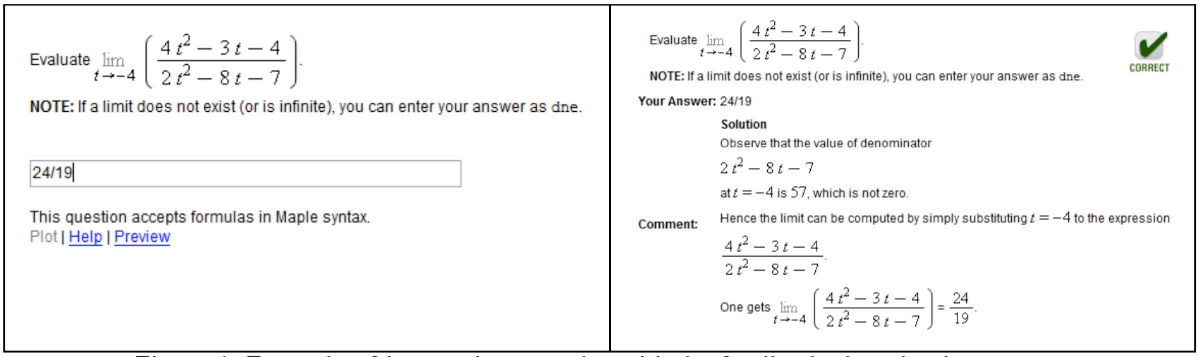

Figure 1. Example of interactive exercise with the feedback given by the system

The Single Variable Calculus course together with its interactive learning materials has been used in Florida State University and in the University of Helsinki where it was given purely virtually and synchronously in a "virtual lecture hall". This was obtained by using an online conferencing system which allows to deliver lectures to students viewing and listening to the lecture with a web-based application. Students can also make questions and comments with a chat or microphone, and the lecture was recorded and made available for later viewing. The implementation of the Virtual Single Variable Calculus course has been recently awarded the Helsinki University prize for technology in education.

The learning materials of a course are divided into *modules* which introduce a specific mathematical concept or method. Students' attention span has become shorter and for this the modules are designed to be compact and provide several activities. The pedagogical design of the course follows John Keller's ARCS model (Keller, 1987) which defines the following criteria for motivating learning environments and materials:

- **A**ttention: the material should arouse learner's interest and maintain it
- **R**elevance: learner should realize why this is important to learn
- **C**onfidence: students should have the opportunity to check whether he or she has learned the subject of the material
- **S**atisfaction: the environment should give positive feedback to the learner when positive progress has occurred.

WebALT courses have been designed to meet these requirements by providing in each module

- a short presentation of the topic, called “Ten Minute Talk”, as a pdf document and a recorded presentation with voice, and interactive laboratories where learners can visualize and experiment – *Attention*
- solved examples that motivate and give applications – *Relevance*
- practice problems that learners can take and later present and discuss in virtual practice sessions – *Confidence*
- automatically graded exercises with immediate feedback – *Satisfaction*

WebALT project developed two ways to present the hierarchy of course modules: a category view where students can browse the material topic by topic and a hypergraph view which gives an overall view of the modules and “zoom” into topics with the mouse. The hypergraph view helps to locate a certain topic for example for reviewing while the category view mainly helps students to go through the material in its natural order. Figure 2 illustrates these views.

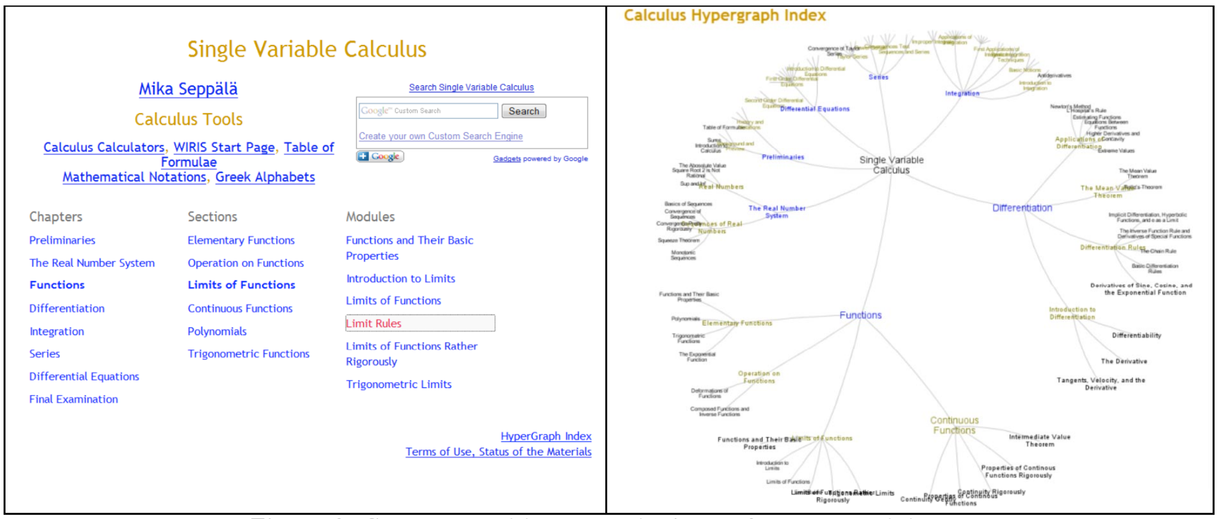

Figure 2. Category and hypergraph views of course modules

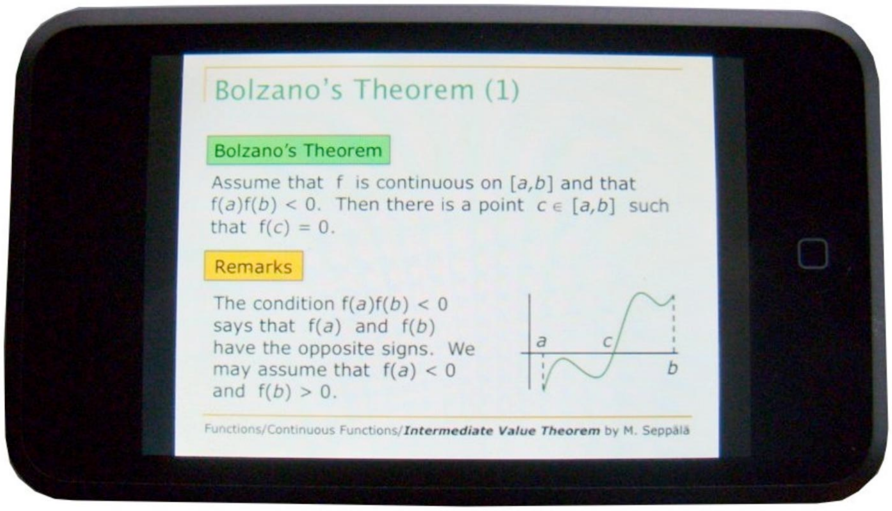

Figure 3. Video lecture played with an iPod Touch

Latest developments of the courses are focusing on adding prerecorded videos to the modules explaining theory and examples. Again these videos should be concise and short yet make the topic or example easy to understand. The production of videos requires careful design of the presented material and its explanation. For example, the feedback of an exercise can link to a little presentation of a general method of solving that type of problems or to its background theory. This type of learning material can be delivered through popular web sites such as YouTube but also podcasted from the course's web site.

Conclusions

The WebALT and JEM projects have provided resources to develop high quality digital online learning materials in a collaborative effort. Additionally, best practices on using these new materials and tools have been shared among the members and institutions of the networks. Several case studies have been carried out in different educational institutions to evaluate the usability and benefits of using the new web based learning environments and resources. This ongoing research gives continuous feedback to make the content and services better and to attain more users.

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