Future of Mathematics Education in Europe at the Tertiary Level

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During 1993-2004, the number of students in Finland has increased by 51%, the number of Master's Degrees 50%, the number of Ph.D. degrees by 167% while the number of instructors has increased only by 2% (http://www.helsinki.fi/lehdisto/raivio.shtml, in Finnish). This inevitably has meant that the quality of instruction and that of the degrees granted has declined. The situation is similar in other European countries.

In mathematics instruction the main problem seems to be how to prepare incoming students to the challenges of mathematics at the tertiary level. Various studies show that, in average, the mathematical capabilities of incoming students have decreased significantly. The main reason for this is the fact that the overall number of students has increased significantly while the sizes of the age groups have decreased.

The problems in the mathematical preparation of high school graduates is universal. In his Executive Order given on April 18, 2006, President Bush established the National Mathematics Advisory Panel. "To help keep America competitive, support American talent and creativity, encourage innovation throughout the American economy, and help State, local, territorial, and tribal governments give the Nation's children and youth the education they need to succeed, it shall be the policy of the United States to foster greater knowledge of and improved performance in mathematics among American students" (http://www.whitehouse.gov/news/releases/2006/04/20060418-5.html).

We need similar action in Europe.

During the last decade the cost of education has risen at a rate which is roughly twice the inflation. While most sectors of the society have become more effective by proper use of information technology, the delivery of education has not. We still teach our students in class rooms in the traditional way, but today the groups, at the tertiary level, are much larger than what they used to be. Because of the greatly varying mathematical abilities of the incoming students, instructors should be able to provide individual attention more than before but they cannot because of the increased numbers of students.

Massive use of information technology in mathematics instruction is the only way forward. High quality mathematical content and advanced learning management systems can be used to offer automatic private instruction. The expertise of the best mathematics educators can be captured in such systems, and a part of mathematics education can be realized at a cost which is only a small fraction of the cost of current education.

The Royal Institute of Technology has led an effort which has resulted to math.se, a web service offering basic mathematics instruction for students entering the tertiary level in Sweden. This has been extraordinary successful. More than 10 000 Swedish students study every year using math.se services. The math.se automated educational services can be offered globally. The only additional cost is in the localization of the content.

In my talk I will describe my views on what information technology can do in mathematics instruction (see http://ubu.math.helsinki.fi:8080/Calculus/).

Proper instruction must implement John Keller's ARCS model:

1. Attention -- the instruction must capture students' attention.
2. Relevance -- the student must find the materials relevant to him or her.
3. Confidence -- the instruction must develop students' confidence in their own capabilities.
4. Satisfaction -- in the end of the educational event, the student must get satisfaction from knowing that he or she has mastered the required content.

I will describe how the ARCS model has been implemented in basic mathematics online instruction at the University of Helsinki.

The eContentPlus Thematic Network, Joining Mathematical Education (JEM) has been set up by the European Commission to advance the use of information technology in mathematics education. Its main activity is the JEM portal (http://jem-thematic.net/). The JEM Network supports all mathematics instructors wishing to use technology.

To develop the high quality content and services is very expensive. To deliver the content and the services, on the other hand, is cheap, and the services can be offered globally. The European Commission has invested seriously to the development of content and services via its various funding programs. The JEM Network is one such effort. More is needed. We need to create a situation which forces institutes to develop themselves. This can be done by fostering competition between educational institutes. Open competition between educational institutes supports the necessary change. Inertia of the Academia is a formidable challenge. It must be faced with decisiveness and sufficient resources.