INDIVIDUALISED LEARNING FOR ENGINEERS: COMBINING FACE-TO-FACE TEACHING WITH NON-LINEAR WEB LEARNING

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How do we meet the challenge of engineering students having different levels and different learning styles? How do we make mathematics and statistics more inspiring? Our approach is to combine face-to-face learning with e-learning. We have developed a prototype for a new kind of e-learning called HEROS (Higher Education Re-usable Objects in Statistics): a non-linear learning object based learning system. Non-linear learning means that the students themselves can design–part of the course–by selecting different learning materials and use them in the order they like. Our learning materials include: an interactive "book", assignments with interactive hints, videos, podcasts, games etc. So far we have developed a continuing education course in basic statistics and right now we are developing a university course in basic engineering mathematic –both based on the principle in HEROS combined with face-to-face learning.

INTRODUCTION

This paper presents two ways in which we have used learning objects combined with face-to-face events for learning mathematics/statistics. The ideas behind this approach to learning are described in more detail in a forthcoming paper by the author, see Rootzén (2010).

The ideas were first developed for continuing education in basic statistics for engineers, but the scope has subsequently become much wider. There is a huge need for flexible continuing education courses based on distance learning. Some of the reasons for this are the widespread use of outsourcing and the multiple locations of today's global companies. This makes it quite a challenge to develop and give courses to all the employees who need them. Ordinary distance courses do not always fulfil the needs because of the common problem that the course participants are on different learning levels and have different prior knowledge and different cultural backgrounds. The challenge thus is to develop courses which fit to and are useful for a wide variety of participants.

However, the same problems more and more arise also in university level courses. When they come from high school, students have quite different prior knowledge, very varied ways of learning, and separate goals. During their time at university their knowledge and skills diverge even more. We therefore propose a new type of course where we combine e-learning with face-to-face learning. Our solution uses "learning objects", self contained "somethings" designed for learning, in a non-linear way. A learning object can be defined as "any digital resource that can be reused to support learning", see Wiley (2000), although we here use the term somewhat more widely to include also non-digital objects such as a oral presentation to be made by the students.

Non-linear means that you can study the different topics in the order you want and choose between different rendering of the same topic – e.g. a video at an elementary level, a "speak" explaining the applicability of the methods, or an applet explaining a part of the theory. Some users will look at examples first and afterwards learn which theories they are based on. Others will do it in the reverse order. Some want to work with problems at first then look at pictures which illustrate the essential parts and then read a text or listen to a spoken explanation. For alternative approaches to non-linear learning see Robberecht (2007) and Morgan & Adams (2009).

We have developed a continuing education course in statistics for a global company based on these ideas and have given it three times with good results. In addition we are now using them in an introductory mathematics course for university students.

To implement these ideas we have developed a system called HEROS (Higher Education Reusable Objects in Statistics) for non-linear web learning.

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php

A CONTINUING EDUCATION COURSE IN STATISTICS

Our first HEROS course is an introductory course in statistics, produced for a global medical company. It is aimed at upgrading employees (mainly engineers), with different experience in statistics, and working all around the world. We have given the course 3 times and in all about 40 students have attended. The evaluations ranged from OK to very good and the exam– in particular the oral part – showed that the students had learned a lot from the course.

An important first introductory and motivating learning object is made by the company. In it key persons from the company explain why the course is important both for the company and for its employees. The central content of the course is "Data" and "Statistical Distributions" – so these are the two main topics – each described in a closely linked group of learning objects. We took pains to see to it that all elements which are needed for understanding really are there, and in a form which is as useful as possible for the student. There is also an exam group of learning objects and a group which gives an introduction to the system.

The main groups each consist of 10-15 learning objects. All are equipped with an inspiration page telling in everyday words what it is all about, and a quiz. The quiz can be taken before starting on a learning object, to decide whether one should invest time in it or if one already knows enough about the subject, and should go on to some other learning object. One can start with whichever learning object one wants to - perhaps the one which one knows the best, or a learning object one is particularly interested in, or a learning object which covers a topic one needs right now. Often there are several learning objects presenting the same topic in different ways, and it is not the intention that a student should go through all the leaning objects; she should just use the ones which suit her needs the best.

The exam uses material specific to the company and is divided into a "multiple choice" and an oral part which is taken in groups. Starting with a real company problem, the groups make an oral presentation of their "solution", aimed at the CEO, a group leader, or a group of workers. The presentation is either face-to-face, or on the web for international learners.

In this first version of HEROS we use Lectora, an authoring tool made by Trivantis (http://www.trivantis.com), and Hypergraph (http://hypergraph.sourceforge.net)–a tool for making a hyperbolic graph which is used to make an overall view of the learning objects in the course.

AN INTRODUCTORY COURSE AT UNIVERSITY LEVEL IN MATHEMATICS

Questionnaires given to the students of the first Mathematics course–Mathematics 1 - at DTU, the Technical University of Denmark, revealed a number of trends in the students study habits. A main one was that the students' use of textbook materials declined as the course progressed, and many students asked for more "present-day" and inspiring supplementary material. A few students suggested that the course should be less "linear" and more like a goggle map. The survey also showed that it is desirable that the course is accessible on "different levels" – i.e. it should be within reach for students with different prior knowledge and quite dissimilar learning styles. The results of the survey very likely can be generalized to many other subjects – in particular to the basic statistics courses. However, basic Mathematics courses pose a particular challenge since they are taken by almost all engineering and natural science students, regardless of what they want to do later on in their studies. In addition the amount of mathematics topics, even at the basic level, is very large, and it is impossible to cover it all, and hard to get a perspective on what one has learnt.

The introductory mathematics course at DTU, the Technical University of Denmark, has around 700 students and corresponds to 17.5 ECTS. It is a modern course with emphasis on Maple - a computer language for mathematical manipulation and visualisation - and functions quite well. Pedagogical improvement is a central interest for the teachers. However, because of the result of the survey and in particular because some students asked for more overview and "non-linearity" we decided to try combining HEROS with the existing course. For this we developed a new system called e*math. Elements of web-based learning in a face-to-face course give the possibility to adapt to individual learning styles and levels in an elegant way. We use lectures plus videos, podcasts, and applets to illustrate the mathematics and to stimulate active learning. So far we have tried this on a small part - one week - of Mathematics 1. The topic for this week was differential equations.

We have evaluated the e*math week very intensively and it seems that the students were quite satisfied with this new way of learning.

CONCLUSION

How do we meet the challenge of engineering students having different levels of knowledge and skill, and different learning styles? How do we make mathematics and statistics more inspiring? Our approach is to combine face-to-face learning with e-learning. Do our new ways of making courses answer these questions? We think that they do, to a large extent. Our future work will make us able to choose between all the different things we have tried out and will hopefully result in an overall "concept" which can be shared by a many courses in statistics and mathematics, and also in courses from quite different areas at DTU.

ACKNOWLEDGEMENTS

The Danish Ministry of Science, Technology and Innovation has supported the work with 3 million DKK.

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