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The Interactive Matlab Course: An Application of Web-Based Learning in Undergraduate Education

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Abstract
This paper presents an obvious application of Web-based education, namely the design of an Interactive Matlab Course. The reason for starting this project was to make our first year engineering students familiar with the design and simulation tool Matlab, by providing them with an interactive Internet environment, which contains the Matlab program itself and all the course material including demos, exercises and tests. The course has been made attractive and tempts students to study anywhere at any time. As a result, the routine-like work of faculty staff members can be reduced. Students' reactions are predominantly positive: the freedom of working at their own pace together with the ability to ask questions during short organized sessions has shown to be both encouraging and effective.

I. INTRODUCTION
With the growing popularity and possibilities of the Internet, web-based teaching is becoming more and more popular in education these days. The new trend focuses on developing more effective and efficient teaching methods for large groups of students by using interactive web-based material [1], [2]. Examples of this type of teaching can be found, for example, in [3]

In 2001, the departments of Mechanical Engineering (ME) and Biomedical Engineering (BME) from Eindhoven University of Technology (TU/e) started to develop an application of web-based teaching: The Interactive Matlab Course (IMC) for first year Bachelor students [4]. Matlab [5] is one of the general computing tools used on a large scale in many parts of both the ME and BME curricula. Especially in the second and third year of the Bachelor study, Matlab is extensively used as a control analysis and design tool in various courses and projects in the curricula. Before starting this project, students used a single guidebook that contained both the study material and the printed versions of the demos and exercises. The possibilities for practicing the demos and exercises was often limited to organized sessions, during which computers were booked and teachers were available to answer questions. With the introduction of the notebook project at TU/e in 1998 (all students have their own powerful notebook from the start of their study, with newest software including Matlab), the idea was born to make the course available on the Internet, so that students had the opportunity to work on the course at any time at any place.

In this paper an overview of the motivations for creating the Interactive Matlab Course is given and it is organized as follows: In Section II, the goals of the IMC will be explained in more detail, after which the structure of the course will be discussed in Section III. The course material will be presented in Section IV and a short evaluation of the past two years will be given in Section V. This paper will be ended by giving some conclusions.
II. GOALS OF THE COURSE

When starting to formulate the objectives for the IMC, its initiators aimed at realizing a few important goals.

Firstly, the subject matter of the course had to interact with some of the classes given in the first year of the curricula, for example the courses Calculus, Linear Algebra, Dynamics and System Analysis. Therefore, a tailor-made course has been developed. That is, the course has been ordered in such a way that the topics treated in each trimester correspond to the content of those classes. This is in contradiction to other Matlab courses on the web, e.g. Matlab courses that are designed to help you learn how to use Matlab for the analysis and design of automatic control systems [6].

The second goal is that the course enables students to work with the study material whenever and wherever it suits them. In other words, they should not be restricted to scheduled sessions where a limited number of computers with Matlab installed is reserved for the course and where staff is available.

Thirdly, the course must be challenging to work with. It has to be designed in such a way that it stimulates students, who might be easily distracted by all nice features of their new notebooks, to read the course text on the Internet and interactively practice with the subject matter using the demos and exercises from within Matlab.

The fourth goal of developing a web-based course is to relieve the university teaching staff from routine tasks. Students doing homework, either individually or in groups, can answer each other’s questions during prescheduled sessions or by using the online forum, that is available on the course’s website. As a result, less coaching is needed and instead of the teaching staff, senior student assistants are called in to monitor the sessions and keep the course material, that is, the website, the demos and the exercises, up to date.

III. STRUCTURE OF THE COURSE

The IMC is structured such that it is very well suited for self-study. Nevertheless, a number of prescheduled sessions is organized to allow the students to ask questions to each other or to the student assistants that are present during the sessions. During the first year of study, six sessions of four hours each are organized, two in each trimester. In each set of two sessions, the students are expected to study two or three chapters of the subject matter, as indicated on the course’s site. In order not to make the course free of obligations, tests are taken during the second session of each trimester. During this first study year, all three tests have to be passed to obtain the credits needed to complete the course. The tests are corrected by the student assistants, under the supervision of a senior staff member. Using this procedure, the staff can concentrate on the innovation of education.

The subject matter of the IMC in the first trimester is quite basic. It covers, for example, working with variables, creating arrays, and plotting data. Furthermore, topics from the Calculus course, such as minimizing functions and root finding, are included. In the second trimester, the IMC has been heavily synchronized with the Linear Algebra course, including elementary linear algebra and differential equations. In the third trimester, the IMC aims at developing programming skills, which are exploited in several other courses in this trimester. Using this structure for the course, the students are expected to have enough skills at the end of the year to use Matlab efficiently and effectively during the rest of their study.

IV. COURSE MATERIAL

To participate in the course, the students use their own notebook. When they work on the course for the first time, they must have access to the Internet to download and install the demos and
exercises, needed to practice in Matlab. After the website has been made available offline, students can study and practice whenever and wherever they want, since no Internet connection is needed anymore. However, in order to use the IMC forum, internet connection is required again. The forum is meant for discussion on all course subjects and is visited by students as well as staff members.

Moreover, providing the course material in website-form, updates can be supplied in a quick and simple way. This material is divided into eight chapters. Each of these chapters describe a certain topic and is divided into (sub)sections, each of them dealing with a more detailed part of the topic under consideration. In some of the (sub)sections, links to demos or exercises dealing with the topic can be found, as can be seen in Fig. 1. Clicking these links will launch Matlab and the demo or exercise corresponding to the link, using Matlab’s ActiveX support.

![Fig. 1. Example of a subsection of the course material. This subsection deals with special matrices and contains links to demos and exercises in Matlab.](image)

The demos and exercises are represented in Matlab by figure files, designed using the Matlab command guide.m (GUI Design Environment). Besides the created Graphical User Interface (GUI), of which an example in shown in Fig. 2, each demo and exercise has its corresponding m-file, which takes care of the execution of the code belonging to the different buttons of the GUI. Examples of these buttons are the "->" and "<-" button, to open the following or previous demo or exercise, the "??" button to show the answer corresponding to the exercise or the "?" button that links to the corresponding text on the web.

Besides from the Internet, the demos and exercises can also be launched directly from Matlab itself using the menu bar, shown in Fig. 2 as well, which is also created using the GUI Design Environment. In addition to the demos and exercises, the study matter on the Internet can also be launched from this menu bar.
Fig. 2. Example of an interactive Matlab exercise. The GUI of this exercise, which deals with special matrices and the GUI of the menu bar are shown, together with the Matlab Command Window.

V. EVALUATION

The Interactive Matlab Course has been used for the first time in 2001. Since at that time the interactive version was not yet completely finished, it was used in parallel with the old version based on a printed guidebook containing the study matter and some of the demos and exercises. In the year 2002-2003, the Interactive Matlab Course was made fully operational and this year was used to remove the last few inadequacies. In September 2003, the course started its second full scale use and to verify whether the goals, described in the section "goals of the course", have been realized, the course will be evaluated extensively at the end of this study year and, if necessary, modifications will be proposed and implemented.

VI. CONCLUSIONS

In this paper, a typical application of Web-based education is discussed. This Interactive Matlab Course guides the introduction into the basics of the design and simulation tool Matlab to first year engineering students. The goals that have been realized, and therefore the merits of this type of education are its attractiveness to students, which challenges to work on it outside prescheduled sessions.

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