Combined Approach to Modelling and Simulation in Engineering Education

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Abstract – **Modelling, simulation, optimization, and control design of dynamic systems are very well established scientific fields which are of crucial importance for engineering education. The paper presents some activities realized through the CEEPUS project cooperation where several countries are involved, among others also Slovenia and Bulgaria. Common project activities include also international summer schools where students and professors from participating countries cooperate through education process. Some experiences and also e-learning development support initiated by such cooperation are described in this paper.**

Keywords – **Control Design, Dynamic Systems, Education, E-learning, Modelling, Optimization, Simulation.**

I. INTRODUCTION

Engineering education programs in most cases include also subjects describing different aspects of mathematical modelling, computer simulation, control design of dynamic systems, and optimization. All mentioned scientific fields are of interdisciplinary nature which means that similar or even completely equal approaches and methods can be used for solving problems from different areas. In addition the level can be adapted to suit all tree education levels: bachelor, master, as well as also doctoral (research) study.

Two years ago, the teaching staff from eight central and east European countries gained the so-called CEEPUS project entitled *Modelling, Simulation and Computer-Aided Design in Engineering and Management* [1]. Through the first year 12 universities took active role in starting the cooperation. Project activities enable also the organization of summer (and/or winter) schools. There are several important goals of such events:

- Students from all participating countries can obtain additional knowledge, representing an extension to their normal study program, which is also indicated in the final diploma certificate in most European countries, representing an important additional motivation for their study.
- Better and more active students have better options when searching and applying for employment.
- On the basis of new contacts established through such meetings, some interesting CEEPUS (but also Erasmus, or similar) exchanges can be organized

for interested students, but also, of course, for teaching staff.

- Lectures and prepared materials offered to students during summer school can represent also the motivation to prepare the improvement of education process for all teaching staff at their home institutions and/or to enable some sharing environment suitable for different institutions and different study programs. This aspect is becoming more and more important because internationalization of studies is becoming increasingly important for all European countries.
- It is also important to mention social contacts which can be improved through such cooperation and which can motivate also additional scientific cooperation between involved institutions.

All mentioned goals contribute also to one very important aspect of education, namely e-learning, which extends existing teaching methodology to blended learning in such a way that education process is improved with some new and convenient possibilities. In spite of the fact that great improvement was made during the last decade, the optimal solution is still under investigation in different countries as well as in different scientific areas. In the paper some possibilities are analyzed which have the potential to represent an improvement of indicated international cooperation.

The paper is organized in the following way. In the next section education process organization at Faculty of Electrical Engineering, University of Ljubljana (FE-UL), Slovenia is presented first. Then some of the most important properties of e-learning program, which was developed at the FE-UL, are explained. In the section III some important information is presented regarding the first CEEPUS summer school entitled: *International Summer School in Modelling, Simulation and Computer-Aided Design,* which was organized at the FE-UL in 2017 [2]. In section IV, the DSS WebOptim is described as a tool for engineering education developed at Bulgarian Academy of Sciences (BAS). The paper ends with some concluding analytical remarks and plans for future work and cooperation.

II. ORGANIZATION OF EDUCATION PROCESS AT FE-UL INCLUDING E-LEARNING PLATFORM E-CHO

The majority of subjects at both bachelor (university and professional) study programs and also at master study program at FE-UL are organized in the form of lectures and laboratory exercises. At the end of the semester, first written and then also oral exams are organized. In some courses also colloquia are prepared during the semester to intensify

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students' work. Very high colloquia's exam grade sometimes means that student has also passed written examinations.

In 2014/15, we have, in addition to the previously mentioned forms, introduced also the e-learning platform E-CHO for all the courses at all education levels. The development of this platform has long been conducted by the Laboratory for Telecommunications at FE-UL. Its efficiency was tested and complemented for the purposes of studies at FE-UL already in previous years [3-5]. Because of many positive experiences further development of the so-called combined or blended learning taking into account new possibilities, is now under investigation. The goals are numerous, but some of the most important are the following:

- gradual subject presentation,
- flexibility and multi-functionality,
- enhancement of motivation,
- step by step improvement of the platform E-CHO regarding specific experiences and arising needs,
- explicit subjects' connections, where possible,
- internationalization of some lectures, courses, or even study programs.

E-CHO is an e-learning Internet-based platform which associates and combines numerous e-learning functionalities. It can also be integrated into other web-based applications. This platform provides e-learning management (LMS – Learning Management System), e-learning content managing (LCMS – Learning Content Management System), tracking of the teacher's activity and progress, knowledge assessment/testing, e-learning standards' support (SCORM and QTI) and multilingualism. During the last few years improved versions of E-CHO were developed where special attention was devoted to the simplification of content development procedures, improvement of progress tracking tools and learning statistics reports, adaptive access – rights management, video and multi – media support, simplified third party integration through open interfaces, new mobile interfaces (tablets, smart-phones), and also improved knowledge assessment (new question types, simplified tests and questionnaires development and delivery).

Each professor and his/hers assistants, as well as all the students of FE-UL, can enter E-CHO through corresponding user name and password information. Starting window is illustrated in Fig. 1. Each professor can develop e-learning contents for the courses he/she is responsible for by clicking the button Classroom (see upper part of Fig. 1). This opens the window of the form as is presented in Fig. 2. In the left part of the window the titles of the subjects are displayed. Below also the access to the short manual is available and some answers to frequently asked questions. Titles of already developed contents are displayed in the next column. It is possible to observe all developed contents or only those which are connected to the certain subject. The user can develop contents in the following forms: file, figure, questions, folder with questions, web-page, url-address, video, different tests, group of contents, course, and video course.
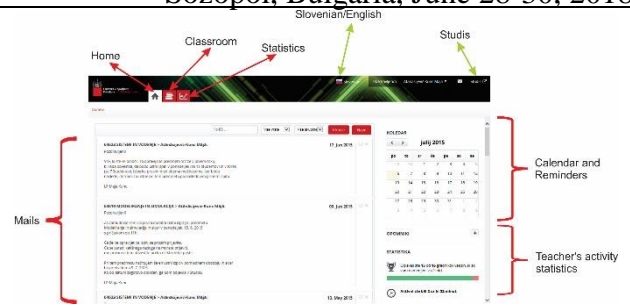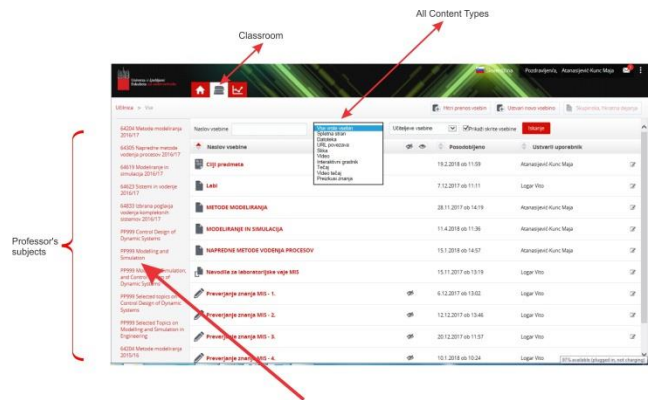

Fig. 1: E-CHO starting window

Fig. 2: E-classroom with professor's subjects and developed content elements

All prepared contents can be connected to one or more subjects in corresponding way. During development or during education process the chosen contents can be made visible only for developers. When desired this status can simply be changed and the chosen content is than delivered to the chosen students' group or groups.

It is important to mention that teaching staff and students can develop contents in the same way. Of course, if students are uploading their homework, projects, or exams these materials can be accessed by teaching staff only, but if their project results can represent interesting information to the whole group, it can also be made visible for everyone from the corresponding group. These properties are important because in this way developed contents can also be combined into different course forms and flexibility of education can be increased.

III. INTERNATIONAL CEEPUS SUMMER SCHOOL

As already mentioned, in 2017, the first *International Summer School in Modelling, Simulation and Computer-Aided Design* was organized at the Faculty of Electrical Engineering, University of Ljubljana. All professors who contributed to the mentioned summer school prepared corresponding materials, which were organized into lectures and laboratory exercises. Prepared materials were distributed among all summer school participants (students and teaching staff) in electronic form and were later also published in a paper form [2].

As all materials were prepared in electronic form we have decided to include them also into a new course-unit entitled *Modeling and simulation* as indicated in Fig. 2 because of the following reasons:

- The form of prepared materials includes lectures and laboratory exercises, which are frequently used education forms at FE-UL, but also at many other universities.
- Prepared materials can be accessed by guest professors from all the locations where Internet is available. They can be used inside the subject or separately, regarding certain situation or usage goal.
- Also the students to whom access is permitted can use the prepared materials.
- It is expected that summer school can be organized again and as material is well organized, also further extensions and/or suitable adaptations can be performed in a simpler and more transparent way regarding all the participants.
- Mathematical modelling is frequently connected also with the experiments involving real and/or virtual systems. Such experiments were already developed for some pilot plants and included into the education process at FE-UL through E-CHO platform [5, 6]. Additional similar possibilities are under investigation [7].
- As E-CHO supports also video elements, further summer/winter schools can be active also in this direction.

It is important to mention that one very frequently used activity (in addition to analysis) in modelling as well as in control design of dynamic systems is optimization. This important chapter can be included in many existing courses at FE-UL. But, an interesting possibility for engineering education represents also the so-called WebOptim tool which was developed at Bulgarian Academy of Sciences which has also participated at CEEPUS summer school and is presented in the following section.

IV. THE DSS WEBOPTIM AS A TOOL FOR ENGINEERING EDUCATION

The decision support systems (DSS) can be considered as a tool, contributing to the modern engineering education. A web-based DSS WebOptim (http://weboptim.iinf.bas.bg/) for solving multiple objective optimization problems has been proposed in [8] and developed (see [9,10]). The system WebOptim is designed in a modular principle, extensively using XML as communication standard and web services. The core system module is an original generalized interactive scalarizing method. It includes thirteen interactive methods. Most of the widely known scalarizing approaches (reference point approach, reference direction approach, classification approach etc.) are realized in the scalarizing method. The Decision Maker (DM) can choose the most suitable for him/her form to input his/her preferences: objective weights, aspiration levels, aspiration directions, aspiration intervals. This information could be changed interactively by the DM during the solution process. Depending on the DM's preferences form the suitable interactive optimization method is chosen automatically.

There are possibilities for distance/electronic education by means of WebOptim for students and post-graduate students in different areas: engineers, economists, persons making decisions (decision makers) in the management of enterprises and production processes, as well as all kinds of experts, who solve optimization problems in their activities (see [9]).

WebOptim may be used as a training system for distance learning (e-learning), providing flexible high qualitative online courses in single- and multiple-objective optimization methods. The solvers engaged in WebOptim allow performance of test experiments on pure continuous, pure integer, as well as on mixed-integer optimization problems.

The system WebOptim may be used both as an educational and as a research tool. For this reason it is designed as an open and extensible system. New methods, solvers, problem types and basically every kind of modules can be added at any time. With an Internet connection the students or postgraduate students can participate in online courses from any location in the world. The lecturer in the corresponding course has prepared series of common accessible examples with attached detailed description of the models and the methods, available for solving each example. It is suitable these series of examples to be used as training aid in the different courses. Starting by simple problems and continuing with always more and more complex problems, in this public profile the student can make steps from the fundamentals to advanced subjects. Each student has online access to the course content.

The system quality (see [11]) of WebOptim using 4 groups of criteria can be evaluated as follows: Group I (Learner Interface): Ease of use; User-friendliness; Ease of understanding; Operational stability; Group II (Learning Community): Ease of accessing shared data; Ease of discussion with teachers; Group III (System Content): Sufficient content; Useful content; Group IV (Personalization): Capability of controlling learning progress; Capability of recording learning performance.

V. CONCLUSION

From the presented the following can be concluded:

- E-learning has become an important aspect of engineering education at many different institutions.
- In spite of the fact that this learning approach has been world-wide adopted many institutions try to develop their own solutions.
- One possible explanation for such situation is the fact that it is also important how different contents are organized into education flow.
- Sometimes also hardware and software available at certain institution are of crucial importance.

- Different teaching approaches using different tools can represent an obstacle in international cooperation where larger number of institutions, teachers, and students should cooperate through such a learning environment.
- It is expected that good experiences in organization of summer schools like the described one inside CEEPUS project can indicate the potential problems but also uncover some good solutions which can also stimulate the development of new and more efficient programs, at least at frequently used activities at engineering field.
- The research of such solutions will also be one of our future goals as it is expected that in this way also our cooperation can be improved.

ACKNOWLEDGEMENT

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