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INTERACTIVE LEARNING PLATFORM FOR numerical methods

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1 Introduction

The interactive learning platforms for many different physics, mathematics, and chemistry (as well as for some other fields) have been created in different universities during the last two decades. The main objective of such educational platforms is to enhance the learning process by providing to the students and teachers the necessary multimedia tools. This has been done through the use of a platform in which the information has been collected, processed and presented in a pedagogical way using several multimedia advantages.

The computerized platform of Energy Technology Dept at the Royal Institute of Technology in Stockholm (KTH, Kungliga Tekniska Hogskolan) contains theoretical sections in the form of several e-pages for each available chapter, with a significant number of related interactive simulations, movies, animations, virtual laboratory exercises, study visits and realistic case studies. Significant background information related to historical development in the field, a display of existing components, nomenclature, multi-lingual dictionary and keywords, as well as questions for self-assessment and exams, an electronic communication group and a local database of the user's "successes and failures", enhance the learning process in a significant way.

The program is intended as a platform for an international collaboration on learning energy technology. It can be used both in the classroom as well as for self-studies and is well adapted for university and post-university learning, self-study, on and off campus, any other forms of study. There are many tools to facilitate the introduction of new material. It is thus hoped that teachers at different universities can join forces and in a non-competitive way introduce material, which can be shared, instead of developing similar simulations with somewhat different interfaces. This collaboration may be beneficial for all parties.

In this paper, the above-mentioned platform is explained and analyzed on examples related to numerical methods for solution of boundary-value problems for partial differential equations, recently developed in this platform. The interactive learning platform gives advantages in a learning and teaching of numerical methods, such as animated solutions of the boundary problems, which show peculiarities for different types of partial differential equations (PDEs), different boundary conditions and numerical schemes for solution of the boundary-value problems. For example, specific properties of different numerical schemes such as stability, accuracy, convergence, etc. are available for instant proof in the practical training by student. The experience showed that students could easily understand the basics presented in short screen forms, which contain the additional information in the form of hypertext (popup).

2 Short descriptions of the multimedia platform and its objectives

The classroom is at many universities today almost nearly the same as it was in the beginning of the last century. The teaching is often provided in the same way and the students are supposed to learn in the same way, although often much more material is today presented to them. Obviously, some technical issues have been changed with the appearance of the slide projectors for photos and overhead slides, as well as with movie- and video-projectors, computers and web cameras. Certainly these aspects enhanced the teaching aspects, but detailed evaluations of the learning improvements are not always performed. Through the hyperlinks they

can access the details described in popup windows or hypertext windows. This is the second level. Then the students can get the whole e-book according to the subject chosen, which is describing all the details like a classical paper book. Thus, some pros and cons arise from this to be analyzed in detail.

Summarizing the above written, we can conclude that the main objective of the interactive learning and teaching is to enhance the learning process of the students by establishing a comprehensive tool**,** which from the beginning has been established as fully electronic, so that it covers all the necessary aspects, which are perceived to belong to learning in a modern environment.

The objective of the present study is to present a tool, which can be used as an international platform for CFD learning, in which teachers from different universities work together with the goal to in a common way enhance learning for students anywhere in the world: a tool to be used any time and any place. Normally many teachers often enhance their teaching with the illustrations using these media, and then the students are expected to grasp the full implications of the shown material immediately, as they do not have the possibility to repeat the experience at their own learning speed, mostly while studying for the exam. Similar with laboratory exercises and study visits. These very often pass by the students as a nice but not very exciting experience in which the students often copy material from colleagues to get it over with as soon as possible.

All various teaching environments are essential and good, and enhance the teaching to a large extent, but the learning is usually less improved. An important aspect is that the "learning by repetition" cannot be achieved as the students often only see some highly interesting material once. Since the personal computer entered into the university environment in the early 1980's, teachers with futuristic views have tried to use this technology as part of their teaching/learning material. Other teachers have totally avoided this new media. The limited experience available related to the use of computers in teaching technical subjects at a university level has shown that the students have probably not learned more than in the classical way.

The experience of using computers in the classroom has often been fairly frustrating for the teacher as they spend a lot of time in preparing the material, which the students thereafter do not use and, moreover, do not at all appreciate the significance of. The fact that most classrooms are not equipped for teaching with the aid of computers is certainly another contributing factor to the many failures in "electronic learning".

3 The methods and tools applied to enhance the interactive CFD learning

Nowadays, the introduction of computerized presentation techniques and overheads has also change the teaching process. This has made possible to show to the students more material related to the specific subject. In special videos, simulations and other multimedia tools represent one of the most relevant changes in the traditional learning. Moreover, the process of teaching and learning in a distant course scheme has been significantly modified. The opportunities and advantages presented by computerized learning are enormous with the possibility enhance the interactivity and thus, the learning. Several computerized simulations have been developed for teaching over the last decades in diverse fields of physics and technology [1-9].

Among the works in this field there can be mentioned Benson et al. (1995, 1997, 1998), Bölcs (1990), Mattingly (1999) and Kurzke (1998). A first preliminary attempt of a totally integrated educational platform that is not limited only to simulations was presented by Léotard et al. (1998). An integrated tool for educational purposes was presented by Fransson et al [2000], which incorporated several multimedia features in one single application devoted to the most important subjects in energy technology, e.g. turbomachinery and gas turbine technology. This

Computerized Educational Platform (CompEdu) has been designed as a stand-alone computerized tool based on the traditional concept of books in which chapters are the main core of the teaching/learning process.

The books are grouped in shelves according with their main subject. There are 6 shelves or main subjects within Heat and Power Technology as Fransson et al [2000]. A toolbar with several additional functions/information is included and can be accessed at any time. This toolbar contains a history part, glossary, quiz and other options. Fransson et al [2000] have explained that each book contains several chapters. Each chapter has a theory part in form of e-pages, videos, simulations, calculation exercises, lecture notes, quizzes, case studies, study visits and lab exercises. The toolbar is available in the theory part.

The use of computer-based learning and multimedia according to Bates (1995) are that it can: present and store information requiring low level and high level of symbolic representation, use a tutorial dialogue (present questions and possible answers to the questions), use simulations (changing the input variables the students can observe the effects on the phenomena under study), allow student's self-assessment (evaluating the student knowledge and thus identify the areas that require further study), combine self-assessment and repetition and allow the student to select the order of material study and pace. Under this philosophy, four e-chapters together with an e-book on numerical methods in energy technology were designed.

The CompEdu platform is not intended to leave the impression of being complete at the present time, although there is already a significant amount of material included. It is instead thought of as a perfect tool for joint educational collaboration in the field of energy technology, with the aim that teachers world-wide will add material, which they consider to be good and unique. In such a way the content will be extended over the next few years. Presently the main emphasize has been put on the 6 "book-shelves" with the upper shelf giving supporting material of various kind and in this particular case, in relation to CFD in the "Turbomachinery" shelf.

The CompEdu chapters and pdf files of the e-book on CFD contain first of all short but thorough review of the basic course on numerical continuum mechanics that is read in the last two years of study in mechanical engineering faculties at most universities. Conscious of the extensive literature on computational thermofluid analysis, the authors have tried to present a self-contained treatment of both theoretical and practical aspects of boundary-value problems in numerical continuum mechanics. First some basic knowledge of university-level mathematics and fluid dynamics is given. To understand the material, the reader should know the basics of calculus, differential equations and algebra. For the advanced reader these chapters can serve as a training manual. Also, it may be used as a guide for practical development, investigation or any particular numerical method, algorithm or computer code.

4 Interactive practical training

Practical training contains computer codes accessible through hyperlinks if student likes to learn programming part in detail. Running computer programs with different input data, student can get basic knowledge about features of the numerical method or physical process described by PDE. Some exercises are prepared in interactive form when student has opportunity to choose parameters in a window and run computer code by button from that window. This option fits well for the students who are not acquainted with programming and like just get basics on application of computer codes for solution of engineering problems.

The other opportunity is given by examples where the numerical algorithm is first described in detail and then the computer code in FORTRAN, which realizes this algorithm, is appended. This supposed to compile the program and then run the executable file to get the

whole procedure of numerical simulation starting from a statement of the boundary-value problem and analysis of the numerical method applied for its solution. Then the student may continue his training working with computer program, which is given with user friendly comments to help student understand it and be able to make changes and perform numerical simulation in a range of parameters.

The students can combine different ways of study according to their needs and individual preferences. They have CompEdu main pages to get basics in short, popups for more information, practical training in two different forms, movies and animated solutions of the problems, etc. For more advanced study the students have also electronic book as pdf file with the whole course on numerical simulation theory, examples of the problems solved, numerical algorithms and computer codes for real scientific and engineering problems.

5 Conclusions

Presently the CompEdu platform is proposed on DVD as well as on-line. The last one is especially valuable for distant education, which is so widely spread in Sweden that since 2001 there was created Swedish Netuniversity.

The information available in the platform is related to the finite-difference solution of PDEs, mainly in fluid dynamics and heat transfer problems. It would be highly appreciated to have collaboration in non-linear problems, finite-volume and finite-elements methods, fractals and cellular automata, LB method, etc. The platform is currently available to teachers for testing and to students for learning, as well as for collaborators for further development and improvement.

References

1. Bates, A.; 1995. “Technology, Open Learning and Distance Education”. Routledge Studies in Distance Education. ISBN 0-415-12799-8.

2. Benson, T.J.; Trefny, C.J.; Walker J.F.; 1997. “Interactive Design Tool for Turbine Based Combine Cycle Engines” AIAA 97-3160.

3. Benson, T.J.; 1998. “Using Computers in Fluids Engineering Education” NASA TM-1998-208810.

4. Boyle, T.; 1997. “Design for Multimedia Learning”. Prentice Hall Europe, ISBN 0-13-242215-8.

5. Fransson, T.H.; Hillion F.-X.; Klein E.; 2000. “An international, electronic and interactive teaching and life-long learning platform for gas turbine technology in the 21st century”. ASME turboexpo 2000, May 8-11, 2000, Munich, Germany. Paper 2000-gt-0581.

6. Léotard P.; Roy, S.; Gaulard F.; Fransson, T.H.; 1998. “Computerized educational program in turbomachinery” asme paper 98-gt-415.

7. Mattingly, J.D.; 1999. “New Software to Support System Approach to Conceptual Design of Aircraft Engines”. AIAA 99-2849.

8. Svensdotter, S.; Almkvist, P.; Fransson, T.; 2000. “Introduction of Project Based Learning for Designing a Heat and Power Plant into the Last Year Curriculum”. Accepted for the ASME/IGTI 2000.

9. Kazachkov I.V., Fransson T.H., Salomón M. Interactive teaching and learning platform for numerical methods in energy/Proc. 41st Aerospace Sci. Meeting and Exhibit. Reno, Nevada 6 - 9 Jan 2003.- AIAA 2003-943.-10pp.