E-LEARNING INFRASTRUCTURE FOR NAVAL ARCHITECTURE AND OCEAN ENGINEERING EDUCATION

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SUMMARY

The mar-ing Network is a joint initiative of the Universities in Germany offering a Naval Architecture and Ocean Engineering study program at master level. Through capitalizing on their complementary educational and research expertise the departments involved aim at further enhancing the attractiveness of the NAOE study program, at decreasing the drop out quota and finally at developing time and location independent further education courses by utilizing new information and communication technologies.

The article outlines the design of this unique network, its background and objectives. It describes the infrastructure implemented to support collaborative teaching in NAOE graduate level courses at the partner universities. Furthermore the e-learning methods found to be appropriate to the special requirements of Naval Architecture and Ocean Engineering are discussed, examples of developed e-learning modules are introduced, and some evaluation results are presented.

1. INTRODUCTION

Networks enable the collaborating partners to combine their competencies and to capitalize on their collective technological and human capacities [1]. Taking into account these opportunities the four German universities offering graduate programs in Naval Architecture and Ocean Engineering (NAOE) joint their forces in the Network of Naval Architecture and Ocean Engineering (mar-ing). Major objectives of this network are to attractively enhance the German graduate and further education programs by collaborative teaching and by implementing new e-learning methods as well as to raise awareness of the excellent career perspectives offered by this industry.

First, the background of the mar-ing network, its partners and objectives are introduced. Second, the special characteristics of the mar-ing e-learning infrastructure are outlined. On this basis the special requirements of Naval Architecture and Ocean Engineering education at graduate level are discussed and the question how e-learning can help to enhance engineering education is answered. In addition a few examples for multimedia-based and interactive e-learning modules developed within the mar-ing network are introduced and different e-learning methods in which these applications can be implemented are described. Last but not least an outlook on student assessment of the developed e-learning modules is given.

2. THE NETWORK OF NAVAL ARCHITECTURE AND OCEAN ENGINEERING

Shipbuilding is of strategic importance for the European countries. It develops advanced technologies that offer considerable spin-offs to other sectors, provides essential means of transportation for international trade and supplies the navies with advanced vessels. In high-tech industry sectors such as shipbuilding, success is first of all based on knowledge [2]. The European as well as the German maritime industry being a major part thereof have clearly identified the importance of highly qualified engineers to meet the challenges of the future [3]. At the same time studies reveal that due to the current age profile of engineers working in the maritime industry and of course due to the technological progress

- the actual number of graduates does not satisfy the needs of the industry and
- a steadily increasing demand of highly qualified naval architects and ocean engineers is anticipated [e. g. 2, 3, 4], see Figure 1.

Being aware of this challenging situation, the four German Universities offering a Naval Architecture and Ocean Engineering study program at master level - Technical University Berlin (TUB), University of Duisburg-Essen (UDE), Hamburg University of Technology (TUHH), and the University of Rostock (URO) - have joint forces in the research and development project “Network of Naval Architecture and
Ocean Engineering” (mar-ing). The research group Instruction and Interactive Media (IIM) at the University of Giessen (JLU) contributes to the project with its expertise in developing learn effective, time and location independent learning scenarios and in securing a high quality of the developed learning materials through an ongoing evaluation and optimization process. The network is funded by the German Federal Ministry of Education and Research (BMBF) and advised by recognized e-learning experts as well as executives of the German maritime industry and maritime associations.

The different core competencies in general engineering and in particular in the fields of Naval Architecture and Ocean Engineering proof the four German universities involved to be complementary and internationally well accepted educational and research establishments. Their wide ranged expertise is primarily based on their extensive research activities: Whereas the Technical University of Berlin focuses on ocean engineering and transport systems/logistics, the University of Duisburg-Essen is specialized in surveying propulsion, ship machinery systems, and inland water vessels. The research activities of the Hamburg University of Technology focus on ship design, hydromechanics, structural mechanics, and ship automation systems and the University of Rostock concentrates on information and communication technologies in ship design as well as on manufacturing engineering and ship maneuvering systems. The differentiated study programs of the partner universities currently provided are an ideal basis for the development of a nationally and internationally recognized network of excellence for high quality graduate and further education in Naval Architecture and Ocean Engineering.

To meet the demand of the maritime industry as mentioned above, the departments involved in the mar-ing network capitalize on their complementary educational and research capacities to impart the required expert knowledge and the methodological skills on the most excellent and well-founded way to a sufficient number of students. Additional goals concern raising awareness of the excellent career perspectives being offered by this industry by ongoing public relations work and enhancing the attractiveness of this course of study as well as decreasing the comparable high drop out quota in engineering education by further improving instructional methods and utilizing advanced learning practices.

The objectives of the mar-ing network are:

- Securing an outstanding and professional education for naval architects and ocean engineers at the participating universities,
- Developing appropriate e-learning modules and methods for teaching naval architecture and ocean engineering students in blended learning as well as in distance learning scenarios at a graduate level,
- Setting up an e-learning infrastructure that supports a close but also time and location independent collaboration of faculty and students,
- Integrating complex analysis and simulation software systems within the e-learning infrastructure so they can be used collaboratively and from different locations,
- Combining the complementary research activities of the four universities in a unique international master program,
- Encouraging internationalization through multilingualism and openness for participation of universities in other countries,
- Taking efficient measures for an ongoing evaluation as well as for a continuous quality improvement in order to secure the sustainability of the results developed.

Thus, the network addresses both

- the qualification for the career entry of naval architects and ocean engineers and
- the further training and education in the dynamically changing procedures and methods of development and production of ships and marine structures.

3. THE MAR-ING E-LEARNING INFRASTRUCTURE

The advanced learning practices developed within the mar-ing network refer primarily to multimedia-based as well as time and location independent e-learning modules and scenarios for teaching Naval Architecture and Ocean Engineering students in blended learning as well as in distance learning scenarios.

Whereas distance learning scenarios can be thought of as completely online a blended learning scenario is a combination of traditional face-to-face lectures and online learning activities. For both scenarios comprehensive multimedia-based learning materials are essential.

The first idea while thinking about an adequate mar-ing e-learning infrastructure was to integrate the already existing learning management systems of the participating universities into one integrated mar-ing learning management system. Unfortunately there are no systems available yet which efficiently integrate different learning management systems and at the same time enable the communication between the users [5]. With regard to the fact that it is not an objective of this project to develop a new learning management system and in order to enable granted time and location independent teaching and student’s access to the developed e-learning modules a central e-learning infrastructure was implemented, see Figure 2.

The major part of this infrastructure is the open source learning management system ILIAS which allows for internet based student’s access anytime and from anywhere and also supports communication and
collaboration between faculty and students [6].

Like other learning management systems ILIAS integrates functions for supporting both blended learning scenarios as well as complete online learning scenarios. At the same time ILIAS is capable of processing metadata and e-learning standards like the Sharable Content Object Referring Metadata (SCORM) [7] and IMS Question & Test Interoperability (IMS QTI) [8] which both support and ease the exchange of learning objects, modules and tests between the collaborating partners.

A streaming server and an application server complete the mar-ing e-learning infrastructure. They allow for short download times when working with data intensive learning materials like e-lectures and for integrating complex analysis and simulation software tools for location independent and cooperative student’s project work. In addition, a lecture broadcasting server as well as an Adobe Connect Server are used which are offered by the German Research Network (DFN) [9] to all German universities conducting e-learning project work.

Since March 2006 the mar-ing learning management system is in operation. At this point 130 students enrolled in any of the NAOE programs of the participating universities have access to approximately 142 e-learning objects (lecture notes, presentation slides, web-based trainings, e-lectures, tests, animations, simulations and maplets – which are described in the following sections).

4. E-LEARNING MODULES AND SCENARIOS FOR NAVAL ARCHITECTURE AND OCEAN ENGINEERING GRADUATE EDUCATION

Engineering study programs in general and the Naval Architecture and Ocean Engineering study programs in particular are on the one hand characterized by partially very abstract learning contents and on the other hand by application specific learning contents. To a large extent this is based on complex mathematical calculations, extensive formula derivation and complex simulations in order to lay ground for practical issues in ship design and production methods [10].

Due to the abstract nature of the learning contents students must be capable of higher level thinking, conceptual understanding and problem solving to adequately deal with it. Therefore, like mathematics education, engineering education requires finding the balance between ensuring that students learn the basics and that they work to develop a broader level of thinking [11]. In this context practice is an essential component while it balances with and enables a larger kind of exploration and understanding of problems due to the deep involvement and the high activity level of the students. At the same time practicing is essential in order to rehearse and master the knowledge required [11]. Another point is that frequent and concrete feedback is required to avoid the development of misleading mental models [11].

Mental models can be understood as cognitive patterns that represent either procedural or conceptual knowledge and help to recognize and structure the full range of attributes and coherences of reality. Thus, they are essential means of thinking [11, 12].

To reach the learning and teaching goals mentioned above diverse multimedia-based and interactive e-learning modules are collaboratively developed within the mar-ing project – with respect to the specific expertise of the partners.

Overall, there will be modules available that correspond to the major subjects: hydrodynamics and stability, ship structures and production engineering, maritime system design, maritime system dynamics, structural analysis, maritime propulsion and machinery systems. In addition, it is planned to additionally offer course materials that promote soft skills like communication and project management, team working, conflict management and fundamentals of business administration. Furthermore, the e-learning scenarios will involve collaborative student’s project work that takes place at different locations including practical tasks like the design of a ship.

The mar-ing e-learning modules are set up modularly, enriched with multimedia-based and interactive elements where reasonable. Thus, they are configurable and applicable in a flexible way so that they can be used either as integral components of traditional face-to-face lectures or as stand-alone courses or additional learning materials. In a second step these modules will be adjusted to the special needs of further education and made available to the maritime industry in order to secure the continuous qualification of the naval architects and ocean engineers.
With respect to the special contents most e-learning methods used in subjects like social science and business administration are not appropriate to adequately support the learning process in engineering education. Nevertheless, the fundamental advantages of e-learning in general and some special e-learning methods in particular are regarded to be appropriate for certain application areas. To give an example, e-learning modules can e.g. provide a wide range and variety of exercises as well as give immediate feedback which supports the practicing, the rehearsal and the mastering. At the same time multimedia-based representations like interactive graphics, animations, and simulations enhance the understanding of the underlying concepts because they reduce the complexity by focusing on one particular phenomenon or on visualizing the overall concept as well as support student’s involvement and activity [12].

4.1 MULTIMEDIA-BASED AND INTERACTIVE ANIMATIONS AND SIMULATIONS

One major component in engineering education is the visualization of physical phenomena, principles, procedures, systems or product structures. Traditionally this is done with the help of graphics, potentially large drawings, sketches, and sometimes videos which do not interactively involve the learner.

Computer-based interactive graphics, animations, and simulations can be utilized to overcome this problem. They can serve as models that represent real processes or phenomena in a simplified way and therefore help the learner to form a mental model of the learning contents presented.

While an animation is a simulated movement created by displaying a series of pictures a simulation imitates a real process or phenomenon. Because of their special nature these applications enhance the understanding of complex learning content. Animation, simulation and interactive graphics can be easily integrated into traditional lectures and seminars but also lay ground for distance learning scenarios and e-learning modules described in section 4.2 to 4.4.

There are at least four essential requirements for animations and simulations that are supposed to serve as models in the learning process [12]:

- Models should be highly accurate and represent the original as adequately as possible as well as indicate the main attributes of the original.
- Models should focus on the essentials for the learning process.
- Models should be adjusted to the specific developmental state and imagination of the learner.
- Models should be as simple and descriptive as possible but exact enough to allow realistic predictions on the original (under certain conditions).

A wide range of animations and simulations already exists. Whereas the simpler enable the manipulation of a single parameter the more complex integrate a couple of interactive parameters which can be manipulated by the student and/or are affected by other interdependent elements. Therefore, animations and simulations are capable of visualizing different parts or complex concepts in a detailed and workable way.

Another advantage is that they can serve as a substitute of phenomena and processes that are either not possible to observe in nature e.g. because these phenomena take place within a complex machinery or that are not possible to reproduce within a lecture due to the high costs involved, see Figure 3.

![Figure 3: Simulation of a Manufacturing Sequence of Flat Panels, M.-C. Wanner, URO](image)

By courtesy of Fraunhofer Application Center for Large Structures in Manufacturing, © 2006

Working with this kind of learning materials instantly shows their superiority to sketches in traditional text books which can not incorporate interactive components.

There are many software applications available that enable the creation of animations and simulations. Very popular within e-learning are the software technologies Flash [13], Java [14] and Maple [15] because of their internet based and browser independent technology. The animations and simulations developed with these software tools can easily be included in the lecture-corresponding presentation slides, web-based trainings and e-lectures (see section 4.2 and 4.3).

Flash is easy to use for the visualization of basic mathematical relationships. However, the creation of more complex phenomena is time expensive and the integration of interactive three-dimensional visualizations is not easily possible, yet. With the help of Java Applets and Maple Worksheets more complex calculations with associated graphics as well as three-dimensional visualizations and simulations can be generated.

Figure 4 shows a screenshot of an interactive flash animation mainly developed for lectures in Hydrostatics and Hydrodynamics. It enables the user to deal interactively with the righting lever curve in combination
with the forces acting on the vessel at the corresponding heeling angle. Different hull form parameter can be manipulated interactively by the user and the effects are shown immediately.

Figure 4: Interactive Flash Animation on the Righting Lever Curve, R. Bronsart, URO

In Figure 5 another Flash application is depicted that is used within lectures on Fundamentals of Ship Structures. It visualizes an interactive main frame in which the different elements can be singled out with additional information displayed. Thereby the additional information is displayed upon the students request and includes not only text but also photos and three-dimensional views of the selected element.

Figure 5: Interactive Main Frame made with Flash W. Fricke, TUHH

Java is very versatile and often used in combination with other software. One example is combining java with OpenGL in order to display three-dimensional geometries that can be manipulated by the user e. g. rotated and zoomed in order to visualize the details and its structural composition.

In Figure 6 a java applet based on numerical calculations done with help of a program implemented in FORTRAN is depicted. While varying e. g. the angel of attack or the profile shape the effect on the flow is visualized.

Figure 6: Java visualizing Fortran Calculations T. Rung and H. Weberpals, TUHH

Another method conceivable for interactively representing complex mathematical relations, its context and for enabling practicing mathematical calculations is with the help of Maple Worksheets which are available through the software package Maple [15]. Maple integrates mathematical calculations and at the same time graphical representations can be generated.

Figure 7: Maplet on Cylinder Motion in Waves G. Clauss, TUB

Based on the MapleNet server component Maple worksheets can be displayed and worked within any internet browser. Figure 7 pictures a maple worksheet on the motion behaviour of a cylinder in waves. The parameters wave height and period as well as cylinder radius and draft can be manipulated. Depending on the input the cylinder moves either in-phase or out of phase.
4.2 LECTURE BROADCASTING AND E-LECTURES

Lectures are an indispensable part of higher education at universities. Unlike reading a book they are characterized by a high level of liveliness, authenticity, and interactivity. Within the mar-ing network two approaches to distribute lectures electronically are utilized. They can be delivered online and offline but differ on their degree of interactivity and time independence.

The first method is based on lecture broadcasting: the traditional lecture at one university is broadcasted by a special videoconferencing soft- and hardware to one or more other universities in different locations (cities). As in a traditional face-to-face setting students can see the lecturer and the presentation slides – either in presence or on a silver screen and listen to him/her live or over loudspeakers. This setting has the advantage that also those lectures are delivered that would normally not be made available at each university because of efficiency considerations e. g. when there is no lecturer on location or not a sufficient number of students taking the course. Another advantage is that the participants can communicate with one another just like in traditional lectures, e. g. discuss further questions on the subject presented. When the broadcasted lecture is recorded and reinforced it can also be provided as an e-lecture.

The second approach relates to electronic lectures (e-lectures, also called m[obile]-lectures) that are basically “bottled” traditional lectures. They include a video of the lecturer in a traditional lecture combined with the presentation of slides, a directory, and eventually links to further information e. g. on the internet as well as a comment function (see Figure 8).

Compared to the production of more complex e-learning applications like web-based trainings (see section 4.3) the production of e-lectures is resource effective and therefore far less expensive.

4.3 WEB-BASED TRAININGS AND INTERACTIVE TESTS

Web-based Trainings (WBTs) play a major role in the context of self-directed e-learning and are normally provided via the internet. They often lean against traditional textbook-contents and are enriched with drawings, videos as well as multimedia-based and interactive elements like the discussed animations, simulations, and interactive graphics [16], see Figure 9 for an example.

Figure 9: WBT with an integrated Flash Animation
M. Abdel-Maksoud and J. Hundemer, UDE

Additionally, there can be exercises and tests included in order to enable the student’s self monitoring as well as to provide an immediate feedback on learning success.

4.4 LIVE SEMINAR TECHNOLOGY

Live seminar technology enables synchronous but location independent collaborative work in small groups over the internet. The participants of a live seminar interact with one another in a shared virtual classroom that is provided by special software tools and communicate with the help of audio and video devices e. g. headset and web-camera. Typically a virtual classroom contains possibilities to upload presentations, to collaboratively work on a shared whiteboard or to work with more than two users with remote desktop connections.

Live seminar technologies are suitable for e. g. online software trainings or for collaborative student project works. Figure 10 shows a screenshot of a mar-ing staff member workshop with the help of Adobe Connect [17].
In order to enable an ongoing evaluation and optimization process the developed e-learning modules are utilized in the graduate programs of the partners as early as possible. They are evaluated with the help of online or paper and pencil questionnaires depending on the preferences of the participating students. The special focus of the evaluation is on user assessment in quality, utility, usability and curricular integration. This formative evaluation is essential for future developments in order to enable early adoptions or corrections in module design and in the general direction of implementing new e-learning methods.

So far six complete courses enriched with multimedia-based contents and partly broadcasted through the internet or distributed as e-lectures as well as four web-based trainings enriched with interactive graphics, animations, simulations and video material were evaluated. Exemplarily some evaluation results of the first web-based trainings within the lecture “Fundamentals of Ship Structural Design” at the Hamburg University of Technology are shown in figures 11 and 12.

6. CONCLUSION AND PERSPECTIVES

The mar-ing Network is a challenging research and development program to develop advanced multilingual, multimedia-based and interactive e-learning modules and methods in diverse fields of graduate education of Naval Architecture and Ocean Engineering. The developed modules and implemented technologies enable time and location independent learning across the participating universities. Especially animations and simulations promote higher level thinking and ease student’s transfer of the gained knowledge into practice and apply it on current practical issues.

Within the scope of this three-year project, a full set of e-learning modules will be developed which in the next step are integrated with complex software analysis tools used in ship design.

6. ACKNOWLEDGEMENTS

The work presented in this paper is supported by the German Federal Ministry of Education and Research under grant 01PQ05001. The authors acknowledge the valuable discussions with all partners and promoters of the “Network of Naval Architecture and Ocean Engineering”.

7. REFERENCES


3. FELLER, C., STAHL, B., ‘Qualitative Anforderungen an die Ingenieurausbildung und die künftigen Bachelor- und Masterstudiengänge’ (‘Qualitative requirements for higher education in engineering and for the future bachelor and master programs’), Impuls, Frankfurt (in German), 2005

4. MARQUARDT R. S., VSM Ingenieurumfrage (“VSM Engineer’s Poll”), VSM (in German), 2005

5. KOHNERT, A., v. PETERSDORFF-CAMPEN, R. ‘Anforderungen an die mar-ing Infrastruktur’. mar-ing: Network of Naval Architecture and Ocean Engineering, Giessen (in German), 2005

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