KISS—A new approach to self-controlled e-learning of selected chapters in Medical Engineering and other fields at bachelor and master course level

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Received 3 March 2005; accepted 20 May 2005

Abstract

Modern life style requires new methods for individual lifelong learning, based on access at every time and from every place. This fundamental requirement is provided by the Internet. The Internet technology promises an increasing potential in the future for e-learning or tele-learning. Some special requirements are password-controlled access, applicability of most commercially available PCs and laptops equipped with standard software (Microsoft Internet Explorer 6.0), central evaluation of the students’ performance, inclusion of an examination part, provision of a picture gallery and a comprehensive glossary accessible in the learning mode. The KISS-shell has been developed based on the Oracle 10g application server in combination with a relational data base (Oracle 8i) on the server side and a web browser based interface using JavaScript for user control of data input on the client side (Kontrolliertes Intelligentes Selbstgesteuertes Studium, KISS). The first tutorial application has been realized with a chapter about cardiac pacemakers. The weight of that chapter (or module) is about 2 ECTS (i.e. the equivalent of 30 working hours; European Credit Transfer System, ECTS). The internal structure of the chapter is organized in sequential mode. It consists of five main sections. Each of those five sections is subdivided into five subsections of comparable length. Progression from one subsection to the next is possible only after successfully passing through the respective examination. The whole learning programme with the pacemaker chapter has been evaluated by 10 students. The system will be presented together with first experiences including the evaluation results. Until now the program has not been used for training purposes.

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Keywords: e-Learning; Sequential programme structure; Performance control; Cardiac pacemakers; Evaluation results

1. Introduction

Today’s engineering students prefer other learning modes than the older generation. Their learning style is characterized by both the disapproval of the traditional face-to-face or classroom teaching mode and the necessity for life-long and self-controlled learning. However, there are more factors that augment the demand for the development of new teaching methods and procedures. The usual lifetime of specialized knowledge in all engineering disciplines including interdisciplinary fields like Medical and Biological Engineering is very short, at present about 5 years (i.e. approximately the time for a two-cycle graduation on bachelor and master level), and it is still becoming shorter [5]. This knowledge, therefore, needs frequent or current updating. Universities should, in accordance with the aims and objectives of the Bologna Declaration, provide primarily the scientific fundamentals of a solid education with a strong focus on labour market qualification [7]. The capability to continue self-controlled learning in special fields after the academic graduation should be properly adjusted to the development in the respective fields and the changing requests from the labour market. e-Learning offers a challenging potential that cannot be utilized if it is only understood as the “electronic representation” of textbooks and lecture manuscripts. It must be tailored to new communication
technologies in such way that quality of learning is improved. The most popular definitions of e-learning are:

- e-learning uses new multimedia technologies and the Internet to improve the quality of learning [8];
- e-learning links Open and Distance Learning (ODL) and Information and Communication Technology (ICT) [9].

E-learning can be realized using different approaches, each with specific advantages, shortcomings and constraints. The two main technologies for e-learning are based either on CD-ROM or the Internet. CD-ROM provides an offline procedure, whereas the Internet renders possible online access with extended possibilities for interactive operation. Considering the target group for e-learning programmes at the bachelor or master level, the most relevant advantages of the Internet based e-learning systems as compared with the CD-ROM based systems (or comparable) are the present and future potential of this technology; the availability of low-cost equipment, the usability of standard software for the platform and the shell, the central control of the individual performance and last but not least the simple updating of the learning material. Taking into account those aspects, the decision has been made for the development of an Internet-based e-learning system.

Another essential aspect is the teaching method. One option is the organization of the hierarchically presented knowledge in a quasi-network structure, which is sometimes called a conceptual network [3]. In that case, the learning process is more or less the “intuitive exploration” of the knowledge “environment” by selecting connections and links from the knowledge center where the exploration tour is started to its nearer or farer environment. The student can determine the extent and depth of the explored knowledge. The exploration method is very similar to the usual search processes in the web and may stimulate the curiosity and play instinct of young people. This method seems to be well suited to fill knowledge gaps and to support the physiological memorization procedure. However, it might be doubted that this method can be used to acquire the complete (or demanded) knowledge in a well-organized structure and with a minimum of time that is required. The underlying learning process is neither systematically controlled nor can it didactically be optimized. The other completely different option is to present the complete comprehensive (and demanded) knowledge in a well-organized structure and with a minimum of time that is required. The following learning process is neither systematically controlled nor can it didactically be optimized. The other completely different option is to present the complete comprehensive (and demanded) knowledge in a well-organized structure and with a minimum of time that is required. The underlying learning process is neither systematically controlled nor can it didactically be optimized.

The database layer is based on a Oracle 8i relational database which contains the learning content as XML-documents, together with all pictures and a glossary that both can be opened in the learning mode. Furthermore it contains the questions and answers for the examination part as well as user status information.

The Oracle 10g application server, including the business logic, is connected to the database using a high bandwidth Java Database Connectivity (JDBC) access. The main tasks of the application server are:

- the control of the password restricted access to user status information and the learning content;
- the provision of dynamically created web pages using Java Server Pages (JSP), including the dynamic linking of images and keywords [2];
- the flow control in dependence on the students’ individual learning progress;
- the error handling.

The application itself has been developed on the Java 2 Platform, Enterprise Edition (J2EE) [1].

2. Methods

2.1. The system configuration

After the decision has been made for the Internet-based technology, the next decisions had to be made for the basic structure and the platform. One of these decisions had been the subdivision into the three-tier-architecture as shown in Fig. 1:

- the database layer;
- the application and business logic layer;
- and the presentation layer.

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The student’s user interface is based on a HTML-compliant client (Microsoft Internet Explorer) using JavaScript for the realization of input control routines and a Java applet as protection measure to prevent downloading of the learning content. For the connection with the application server only the Hypertext Transfer Protocol (HTTP) is used to avoid conflicts with intermediate firewalls. The administrative interface is also based on a web browser and mainly responsible for XML uploading (learning content), image uploading and content management.

2.2. The shell

The shell determines how the information is presented and controls all procedural steps. The teaching module consists of a part A (general instructions), part B (learning material, organized in sequential mode), part C (examination), part D (glossary) and part E (tables or figures). The schematic diagram is shown in Fig. 2.

When a user is logging on, the system checks the authorization before access to part A is permitted. From part A the user can continue to part B, the learning content. He can gain a survey on the whole learning material and start with the learning process, either with the very first subsection or, if he has already successfully completed some subsections, with the next subsection. The time for working in the learning material of each subsection can be limited. If that time is over, the user can either start with the examination or quit without examination. In the latter case, the student will start at the next access with the same subsection for which he has not completed the examination. As long as the student is working in the learning mode, he has free access to all pictures in the picture gallery as well as to all keywords in the glossary. Those pictures and keywords which are of special relevance to the respective learning material are indicated in the text, the pictures in thumbnail size. By clicking on a thumbnail, the picture is presented in actual size. By clicking on a keyword the whole explanation for this keyword is presented. Leaving the picture gallery or glossary brings the user back directly to the place from where he has left to the gallery or glossary.

The logon time as well as all other user interactions (entering the learning mode, starting and finishing the examination, logout, . . .) are recorded by the application server and are stored in the database so that they can be considered for the performance evaluation.

After entering the examination part, the student cannot visit the picture gallery or the glossary anymore. The student can continue with the next subsection only if he has successfully passed through the examination part. Also the time for the examination can be limited and, if surpassed, yields a break that requires a new start in the learning part of this subsection. The time that is used for passing through the examination is also recorded for performance evaluation. If the student fails to pass successfully through the examination, it depends on the ”weight of failure” whether the student...
Fig. 2. Schematic diagram of the KISS-shell. The system consists of 5 main parts: (A) logon and general instructions; (B) learning material; (C) examination; (D) glossary; (E) table of figures.
has to go back only to this last learning subsection or to pre-
ceding subsections which he had already completed and now
has to repeat. In the latter case, i.e. for already completed
subsections he has to pass again through the examination.
If the student passes again through the same examination,
the multiple-choice questions will be the same, however the
order of the questions and answers will be changed. It will
be recorded which “false” answers have been chosen by the
student.
The student can interrupt at any time both in the learning
and in the examination mode. With his next access he will
start always in the respective learning subsection. The time
of the interruption will be recorded.

2.3. The learning material

For the first practical evaluation a chapter about cardiac
pacemakers has been chosen because it meets different
requirements [4,6]. Its understanding requires a broad
knowledge base both in the medical-clinical and in the
physical-engineering field, the knowledge can be repre-
sented as a specialized subfield that can be well separated
from other subfields, this knowledge can be properly
organized in the sequential mode, the advancement of the
knowledge in that subfield is pushed by a challenging and
fast-developing high-technology, and technological and
clinical relevance of that subject has attracted great interest
from the students (at least in Graz).
The five main sections are:
(A) Anatomy and mechanics of the heart.
(B) Electrophysiology of the heart.
(C) General function, technology, classification and design
of cardiac pacemakers.
(D) Special functions and advanced technology of cardiac
pacemakers.
(E) Problems and complications.

Each main section is subdivided into five subsections of
comparable length. The length was chosen in such a way
that the total working time for both the learning mode and
the examination for each subsection will take approximately
1.5 h. This is the time equivalent with two “academic” hours
for classroom presentation. Therefore, it was assumed that
the students might be able to learn one subsection during
that time with full concentration and without getting tired
too much.
The total time requirement was assessed to be about
37–38 academic hours. The recommendation is that 1 ECTS
shall be equivalent with 15 “academic” hours. It must be
considered, however, that usually for regular lectures addi-
tional time is required for the preparation of the examination.
In the described e-learning programme the examination is
already an integrated part and does not need additional
time for preparation. Therefore, this described e-learning
programme for cardiac pacemakers may be equivalent with
2 ECTS.

3. Results

3.1. The evaluation procedure

The complete system with special regard to the shell and
the learning programme has been evaluated by 10 engineer-
ing students on voluntary basis. Most of the students were
in the 3rd or 4th year of the regular 5-year curriculum. Only
few of the students had already some knowledge on cardiac
pacemakers, most of them, however, had good knowledge in
general anatomy, physiology and fundamentals of biomi-
cal engineering. The students were asked to use their private
computers for the evaluation. This employment of different
“private” computers was requested in order to identify tech-
nical shortcomings and constraints. The information about
the required properties of the computers and software had
been supplied to the students in advance, but actually only
rather low standard performance was necessary. The mini-
mal performance requirements are a personal computer with
an Intel PII-350 MHz (or equivalent) processor, 64 MByte
main memory and Microsoft Internet Explorer 6.0. The Inter-
et connection bandwidth should be at least 56 kbit/s. The
students had not been selected as Internet specialists, actu-
al they they had “average” level expertise about the use of the
Internet. Some of the students had excellent experience with
software development for different applications, other stu-
dents had no real experience in that field.
The students had been provided with all background infor-
mation including the purpose of the evaluation. Successful
completion of the evaluation procedure was recognized by
a mark as usual for courses. However, the mark was not
related with the recorded performance, e.g. how much time
was needed for learning or completing the examinations,
how many repetitions were required for successfully pass-
ing through the examination. This mark was determined
only by the fact whether the students have given marks to
different features which had been identified and by their
comments which should be given in free style. The students
were encouraged to submit critical comments and to propose
improvements to all aspects where necessary or desired.

3.2. The evaluation results

All 10 students have completed the evaluation and given
marks to the identified features. Most of the students have
submitted more or less extensive comments in free style.
Most of the comments have been coupled with proposals for
improvements.
Evaluation of the features should be executed in a scaling
mode with 1 = excellent, 2 = very good, 3 = good, 4 = poor,
5 = insufficient. The following features had been asked (the
scaling mark is the average for all 10 students):
1. Comprehensibility of the introductory and operating instructions 1.8
2. Didactic organization and presentation of the learning material 2.3
3. Relevance and completeness of the learning material 2.7
4. Support provided by the figures in the picture gallery 4.2
Most of the critical remarks were related with technical problems to open the full-size figures. Other problems occurred by returning to the original position in the learning material. These technical problems explain the rather poor marks for the features No. 4 and 10. Some suggestions for improvement were obtained to features No. 6 “User friendliness” and No. 10 “Operability”. Those remarks underline the necessity to test such programmes on a multitude of different computers if students work on their private computers. A strong suggestion from many students had been to permit access to subsections which had already been completed without the necessity to pass again through the examination of that subsection before returning to the left subsection. This request is comparable with the possibility to go back in a book to a preceding chapter. Another suggestion had been that the running time for both the learning part and the examination part should be presented on the monitor. Most of those suggestions were really helpful for improved user friendliness and have been realized. Only few suggestions which would have restricted the controlling function and the recording of the individual performance were not considered.

From the records it became obvious that most of the students were working on the learning programme late in the evening, during the weekends and the Christmas holidays.

4. Discussion and conclusions

There is no doubt that e-learning, especially Internet-based tele-learning, will gain increasing importance in the future for regular professional and academic education as well as for life-long continuing education. Until now only few experiences are available which approach might be the best and most acceptable for different target groups and learning materials. For this reason, the experience and results acquired with a certain system might be valid only for that system. The described system presents the master-level specializing learning material about cardiac pacemakers in the sequentially structured mode with an integrated examination part, picture gallery and glossary. It allows to record the students’ performance for evaluation purposes.

The resonance by the students who have executed the evaluation was very positive to that approach despite some critics, mainly on the technical features and performance of the system. Thanks to the careful evaluation by the students, the technical performance has been improved and problems with some unclear formulations in the learning material have been removed in the meantime. Other students who have been informed about the e-learning programme by the participating fellow students have requested to make it available for them in the near future as a regular educational e-learning-based course.

The shell is not limited to any special properties of the actually evaluated learning material. At present other students are developing the learning material about telemedicine which shall be presented in the same shell. In that case different sections like “teleradiology” and “telehomecare” cannot be organized in the rigid sequential mode. It is interesting to see how students prepare the learning material for their fellow students. Based on this experience it is felt that e-learning with an appropriate shell encourages students to become “electronic tutors” for their student fellows. The time that was necessary to prepare the whole learning material, the questions and answers, the glossary and the picture gallery was about three to four times the time for preparing the same material for a regular classroom presentation.

Although this is a preliminary report based on first experiences, the results are stimulating and underline the large potential of Internet-based e-learning.

References