Anytime, Anywhere Learning Behavior Using a Web-Based Platform for a University Lecture

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***Abstract*—Web-based educational platforms offer a broadly accessible interface to foster information dissemination and interaction-based learning anytime and from anywhere. Accomplished by the availability of a wireless communication infrastructure like IEEE 802.11b or GSM/GPRS and the use of mobile devices, University students are able to make the first steps towards ubiquitous learning.**

To stay abreast with the adaptation of learning styles using new media, we created and used a Web-based online-learning platform in our lectures. The platform offers guided discussions, integrated access to content information and tracking of the individual student's status. To allow just-in-time feedback and a variety of communication styles, synchronous and asynchronous means for interaction is provided. The main objective in this paper is the evaluation of the effective students' behavior using our learning platform based on qualitative students' feedback and quantitative analysis of the students' self-assessment. To conclude our evaluation, we show the actual user behavior by analyzing database access and access log files.

***Index Terms*—e-Education, Web-Based Learning, Ubiquitous Learning, Case Study and Evaluation.**

I. Introduction

Ubiquitous computing refers to a situation in which a multitude of connected and embedded systems and devices work together to build an ambient computing environment. Not only business and private life will change using ambient intelligent environment, it is as well expected that University education will change significantly towards a more situated and context aware educational style.

Being connected to a computing infrastructure allows both to access learning content from anywhere at anytime, and to communicate with colleagues or lecturers synchronously and asynchronously much more frequently. Thus, lectures enhanced with accompanying e-Learning facilities are favorable compared to traditional lectures.

To evaluate the need and the acceptance of lectures enriched with distance learning functions, we designed and implemented a Web-based learning platform. In winter term 2001/02, the platform was deployed for business informatics students at the University of Vienna.

We present an overview of ubiquitous learning and the expected learning scenarios in section II, followed by a detailed description of the learning platform and its design principles in section III. An evaluation of the students' feedback both qualitatively and quantitatively is presented in section IV. Furthermore, in this section, the students' self-assessment is compared to Web log file entries and database accesses. To evaluate the learning situation not only from the students' point of view, the access behavior of the lecturer is analyzed as well to show the teaching workload over time.

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II. Anytime, Anywhere Learning

The existing learning environments are widespread, running from *Computer Based Training* (*CBT*) packages to complete accompanying learning platforms commonly based on Internet technology [1]. It has not yet been proven that distance education is suitable for students or that distance learning may replace traditional lectures. On the other side, traditional lectures may be enriched by new media, like using mobile devices like PDAs in classroom to increase interactions e.g. introduced by the Mobile Learning project at the Northern Alberta Institute of Technology [2].

It is foreseen that hybrid e-Learning solutions will most probably survive and will turn into m-learning solutions as devices will become more and more mobile. To allow seamless integration into a shared learning environment, the underlying wireless network must provide reliable connectivity. A shared environment may either be an infrastructure scenario, where students access an existing platform to e.g. take a look at their marks, or an ad-hoc learning scenario, where students meet and exchange e.g. files directly using a P2P mechanism, like e.g. JXTA [3], UPnP [13], and the ad-hoc-networking mode of W-LAN or Bluetooth.

A. Web-Based e-Education

Computational support in education should cover four aspects, namely (i) *content delivery and simulations* (like downloadable papers, video presentations, simulators for understanding e.g. physical processes and properties etc.), (ii) *synchronous and asynchronous communication facilities* for students and lecturers, (iii) *support for testing and status reflection* for the students and (iv) *collaborative group support* like e.g. support for annotations, discussions and project

oriented teamwork.

Thus, e-Education fits to a multitude of learning theories focusing on flexibility in time and space and student-centered learning. It is possible to support e.g. *situated* cognition (or situated/anchored learning [4],[5]), where it is argued that students learn most if they solve authentic problems of personal interest based on constructivism. New media may help to organize, distribute and put together the results based on personal interests by e.g. using Web space for publishing multimedia enriched literature researches or to present solved problems. Besides, collaborative learning is another promising approach which is perfectly supported via learning platforms and computational appliances [6]. Using a Web-based learning platform, students and lecturers may communicate via commonly known browsers to share problems, ideas and solutions in an informal way. However, since learning is a social process, introducing means for expressing emotions, taking different roles or allowing feedback are still immature in learning platforms. Furthermore, motivation and guidance based on the personality of the lecturer (or other students) is often neither considered nor supported.

B. *Ubiquitous Learning*

Using a ubiquitous and mobile supporting infrastructure, a multitude of new situations arise and may be supported by the learning platform. Besides the requirements and learning techniques addressed by e-Learning, location dependent knowledge and situation dependent support are added.

Mobile learners may be differentiated into actually moving persons or being temporary stationary just using a mobile device. Most probably, roaming students are rather not concentrated or short-term-focused learners, but they may use resources currently in the line of sight or radio coverage, like a poster or a solution for an exam on the table or on the screen of a notebook in front of another student using ad-hoc networks. In contrast, learning sessions of temporary stationary students may last a few hours and are comparable to traditional e-Learning settings at home, except perhaps the lack of concentration due to environmental sensations at the University campus or in a cafe.

Using wireless network technology, like e.g. GSM/GPRS or W-LAN, mobile students depend on the availability of the network (e.g. W-LAN hot spots at the University campus, cafes, airports, etc.), the bandwidth and the costs. In addition to the increasing number of W-LAN hot spots, future cellular networks will help to provide coverage with broadband wireless technology (3G at 144Kb/s mobile and 2Mb/s static; 4G at 2Mb/s mobile and 10-600Mb/s static [11]).

Furthermore, the display of mobile devices is usually smaller and the battery performance is still not convincing. Therefore, such devices cannot be dispatched for time intensive use, but the learning modules and items have to be split into small and fitting unities and the presentation is supposed to change depending on the capabilities of the device. Thus, here the separation of content and presentation is a main design requirement.

It is expected, that the enabling technologies foster a paradigm shift in learning, stressing on communication, direct and on demand exchange of information between students and lecturers just-in-time. As a consequence, we will be able not just to accompany beginners while becoming competent students, but also to enable and support students to become experts when handling authentic and complex problems [7], which is a main goal in University education.

III. Distance Education via a Web-Based Learning Platform

Whenever e-Learning is discussed, distance learning approaches are compared to approaches that support students with wired and wireless technology in class. Since our lecture is a laboratory course about concepts and programming of distributed systems, learning is highly focused on self-study and working in teams. Hence, we decided to focus on supporting distance learning.

A. *Platform Architecture*

There are several good reasons for choosing a Web-based platform for our experiment. First, the Web is accessible almost from anywhere via an arbitrary browser. Secondly, *HTML* combined with *Java Applets* provide sufficient accompanying support for a laboratory course, where content provisioning and delivery is much less important than the students' work and discussions on selected topics.

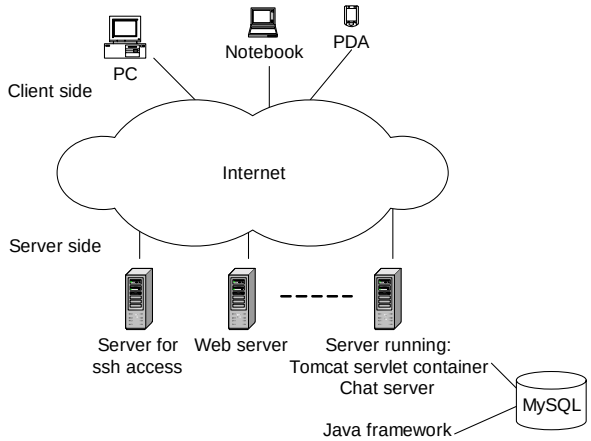

Figure 1: Web-based learning platform architecture

To support different types of devices with different capabilities, like the display size, the platform is easy to use and uses a simple interface. Thus, it is accessible from any Java enabled Web browser. The whole platform consists of Web pages and most of the content, like student data, lecture content and contribution to the different forums is retrieved from a *MySQL* database. Java classes and the *JDBC/ODBC* bridge are used for database access and *Java Server Pages (JSPs*) [8] are used for producing the presentation, i.e. the Web pages. Due to the security and Web server policy of the department, we use a Web server as a general portal and a *Jakarta Tomcat server* [14] on another host as a servlet

container. In addition, an *ssh* server has to be used for remote login to the student teams' home directories, allowing data transfer or running applications remotely. Lastly, we are glad to use the 3D chat program *VisualChat* [9] consisting of a chat server waiting for requests from client Java applets. Figure 1 shows the architecture in detail.

To allow session management, cookies or URL rewriting are used to provide a personalized and convenient access for the students.

B. *Course Structure and Student Interface*

Based on the architectural concept, the learning platform supports a laboratory lecture on distributed systems in all phases: (i) the first part where the students discuss principles of designing and programming distributed systems, (ii) followed by the part learning to use Java RMI, and (iii) finally, the students develop a Client/Server application based on Java RMI.

The online-learning platform has been used via PC, notebooks and has also been proven usable on a PDA (e.g. COMPAQ iPAQ H3600).

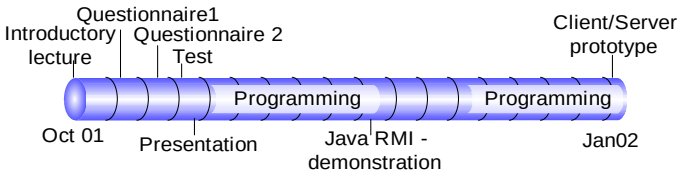

Figure 2: Lecture timeline

Figure 2 shows the lecture milestones on a timeline, starting with a introductory lecture in class and followed with two deadlines for answering and discussing selected questions on distributed systems and a test at the end. The questionnaires are fully online, i.e. students discuss distributed systems topics while answering the prepared questions, posting additional questions or answering questions of other students in the questionnaire section.

In the second phase, after a presentation on Java RMI programming, a demonstrator is programmed by teams of four students. To provide collaborative working, each team is assigned its own group forum, which in this place should be used as main communication tool. Furthermore, the open forum and the chat room are open for discussion about arising problems between the students and the lecturer. The demonstration of a running Java RMI program enables the students to build a Client/Server prototype in the following month.

During the whole lecture, the platform provides synchronous and asynchronous communication facilities (chat, open forum, group forum). One hour per week at a fixed time, the lecturer is online in the chat room. Furthermore, students' status information retrieval, a feedback function for students to express their satisfaction immediately, organizational information and content information in the download module (manuals, papers, etc.) are supported.

Figure 3 shows a picture of the platform, containing the user interface of the feedback facility in detail. On the left hand side, the menu items navigate through the platform [10]: (i) *Home* navigates to the news section and the introduction to the lecture; (ii) section *Schedule* gives a brief overview of the timetable; (iii) item *Work* guides to task descriptions, to the online questionnaires and to the downloadable content section; (iv) item *Contact* gives information on how to contact the lecturer and when to reach her/him in the laboratory; (v) *e-mail* invokes the mailing facilities of the browser and the installed mail client, (vi) while the item *Chat* leads to the chat room and (vii) *Forum* refers to the open forums of the platform; (viii) item *Group* leads to a closed group forum for the respective group members; (ix) finally, *Status* allows the students to know about their current efficiency rating anytime, and (x) item *Feedback* leads to a mood barometer and allows the individual student to give a short feedback whether he or she is satisfied with the support.

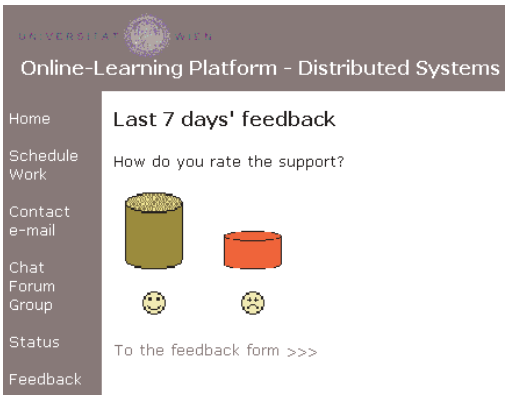

Figure 3: Screenshot of the platforms' feedback section

The menu items (vi) – (x) require a login (using an account and a password). The login name is either freely chosen by the student or an appealing name is assigned by the lecturer. Using these nicknames instead of students' identification numbers or real names provides anonymity to a sufficient degree. It is worth mentioning that the platform provides simple social interaction facilities as well, using emoticons expressing the students mood which may be assigned to each posting.

C. *Administration Interface*

The administration modules are organized on the same architectural basis as the student interface modules, using JSP for presentation generation and using the MySQL database. The administration interface is used to create, change and delete (i) lectures, (ii) user data (i.e. student data like marks, e-mail addresses, etc.), (iii) user groups with different capabilities (admin, user, guest) and, (iv) forums and their properties. It facilitates mainly the change of student data during the semester.

IV. EVALUATION

The platform was deployed in winter term 2001/02, where 64 students attended the lecture. Generally speaking, the platform runs very stable, the servers (Web servers and chat server) had to be restarted only once within 4 months. Some browser problems were reported by students, but could not be reconstructed.

The online-learning platform has been used via PC, notebooks and has also been proven usable on a PDA (e.g. COMPAQ iPAQ H3600).

A. Qualitative Student and Lecturer Feedback

Using the learning platform was a new and motivating setting for both the lecturer and the students. During the first phase, the students answered vividly the questions given in the online questionnaire. However, at the beginning they did not react to postings of other students and did not question any statements of others. Firstly, this behavior showed that the students were not familiar with discussing computer science topics, and secondly, the students had to find out how and where to place their contributions. On the other hand, the students soon assisted one another with meta-information postings in the open forum, e.g. how to structure the postings.

During the programming phase, the students did not use the platform to a large degree any more. In case of problems, mainly the forums were used to distribute the questions and to look for answers and suggestions from other students. The chat room was sometimes used as a kind of (programming) hot line or for asking short and precise questions. Generally speaking, the synchronous communication facility (i.e. the chat room) was not as frequently used as the forums. Unexpectedly, the group forum was not commonly used by the programming teams, most probably because the teams used their own private media for communication.

B. Students' Self-Assessment

At the end of the semester, an interrogation of 54 students based on a questionnaire has concluded the lecture. The evaluation of the interrogation (each student has been asked for one vote for each topic) is presented to argue whether or not the students have been satisfied with the platform using the categories: *very low*, *low*, *medium*, *high*, and *very high*.

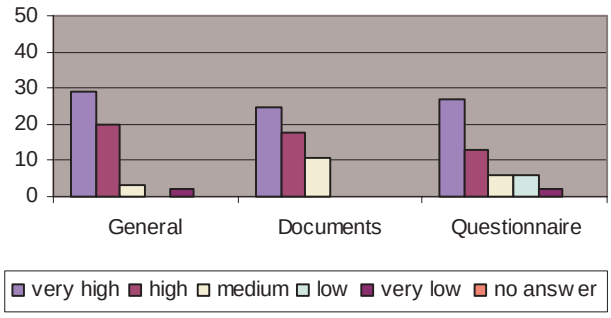

Figure 4: General and work support

	General	Documents	Questionnaire
very high	29	25	27
high	20	18	13
medium	3	11	6
low	0	0	6
very low	2	0	2
no answer	0	0	0

Table 1: General rating and work support numbers

Figure 4 shows that the students have been generally satisfied to a high degree (*General*). They appreciated discussing on distributed systems' topics (*Questionnaire*) and rated the structure and the content of the download area (*Documents*). Table 1 shows the students' votes in detail.

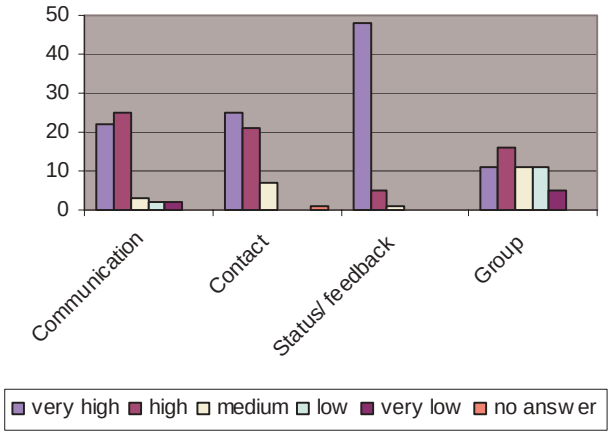

Figure 5: Interaction support

	Communication	Contact	Status/ feedback	Group
very high	22	25	48	11
high	25	21	5	16
medium	3	7	1	11
low	2	0	0	11
very low	2	0	0	5
no answer	0	1	0	0

Table 2: Interaction support numbers

Since the platform offers a multitude of means for interaction and communication, the satisfaction with the interaction features are presented. Figure 5 shows the students' ratings on the *Group* forum, which was not appreciated as high as expected and the communication facilities including chat and the open forums (*Communication*). Being a related subject, the evaluation of the means to contact the lecturer and the quality of the lecturers' answers, like the forum or e-mail, showed a slightly higher appreciation and indicates that the physical/personal contact was not missed to a high degree (*Contact*). The features allowing the students to keep track of their current status and the possibility to give feedback immediately were very much appreciated (*Status / feedback*). Table 2 shows the numbers in detail.

Finally, we asked for the access frequency and the access behavior, as shown in Figure 6. Most of the students estimate their access frequency in the range of 5 to 9 times per week (*Access frequency* per week – very low: 0 times, low: 1 to 5 times, medium: 5 to 9 times, high: 10 to 14 times, very high: more than 15 times). It is worth mentioning, that most of the students access the platform from at home (*At home)*, a few from the University campus (*At campus)* and a few while being at work (*At work*). Thus, mobile students occur rather rarely. A possible argumentation may point on the absence of an area-wide W-LAN coverage at the University campus or W-LAN hot spots. Table 3 shows the ratings in detail.

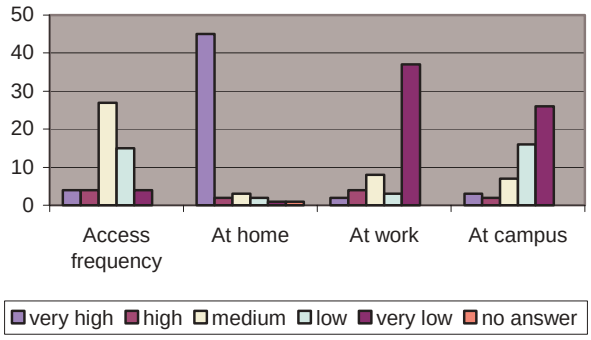

Figure 6: Access behavior and frequency

	Access frequency	At home	At work	At campus
very high	4	45	2	3
high	4	2	4	2
medium	27	3	8	7
low	15	2	3	16
very low	4	1	37	26
no answer	0	1	0	0

Table 3: Access behavior and frequency numbers

C. Evaluation of Log Files and DB

By analyzing the Web server pages and database entries, the temporal behavior of the students and the lecturer has been examined.

Figure 7 shows the number of postings per day related to the questionnaires, which were to be answered at the begin of the lecture. This curve explains the first part of the lecture well. The questionnaires were separated by one week. For the first questionnaire, the students showed more interest, probably in order to secure the passing of the lecture and to learn how to deal with the e-learning environment. After having successfully posted answers, students lowered their interest and posted at a much lower rate. The lecturer posting rate stayed roughly constant, with peaks shortly after the start of each questionnaire and after its end. Furthermore, the curve shows how the lecturer's effort (in positive answers and new questions) influences the activity of the students positively.

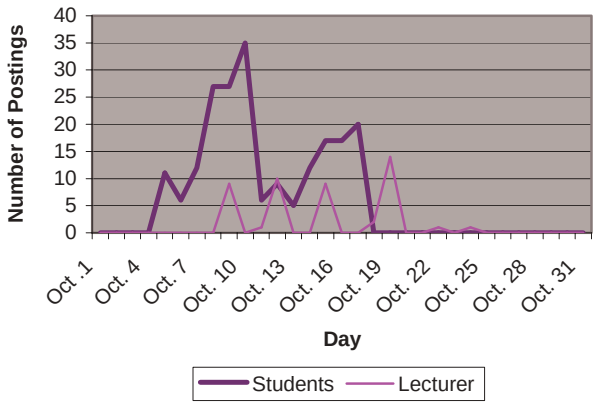

Figure 7: Number of postings (per day) related to questionnaires

Figure 8 shows the number of forum postings per day, not related to the questionnaires. Again, the students at first make heavy use of the forums, but loose interest after a while. This is probably related to other communication means that are used for managing the programming efforts. Only at the end of the lecture, the students again use the forums as means for communication. As can be seen, the posting curve of the lecturer follows the students with a delay of one or more days. The lecturer here mainly reacts to student postings by communicating important information that has been asked for.

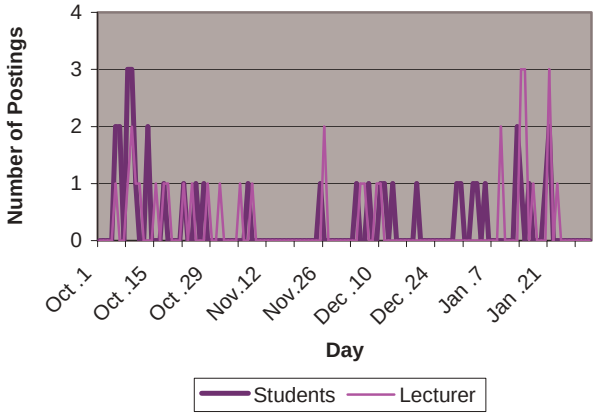

Figure 8: Number of postings (per day) related to other forums

Figure 9 shows the number of Web site hits of JSP documents per day. The "Admin" curve denotes administrative work, whereas the other curves denote Web downloads of the user sections, showing both student and lecturer downloads. It can be seen that the student workload is first high, but drops significantly at the middle of the lecture. In this phase, the students had already passed the questionnaires and had informed themselves of the requirements for the programming

tasks. Once being informed, the students focused on their programming work and needed no further information from the platform. The Web downloads of the lecturer stayed roughly equal during the course, with peaks being correlated to the administrative tasks.

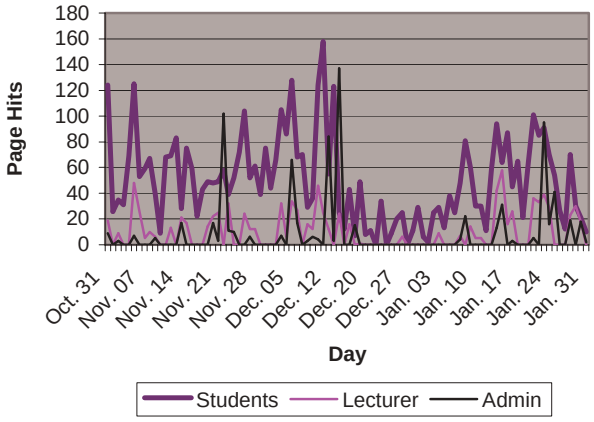

Figure 9: Number of Web hits per day

Administrative work shows distinct peaks equally distributed through the course. Administrative work was done after the questionnaires, slightly before the start of the programming tasks and at the end of the course, with almost no work necessary in between.

V. Conclusion

Based on our believe in collaborative learning and the need for guiding high quality discussions in computer science curricula, we introduced a Web-based online-learning platform to support a laboratory lecture about distributed systems. Access to the platform is granted via a Java enabled Web browser from anywhere, anytime. Thus, students are enabled to communicate synchronously and asynchronously, to access their current status and information and to solve the exams and programming exercises. Furthermore, the students may give feedback about their satisfaction with the lecture support immediately and in a simple way.

We evaluated the students' access behavior during winter term 2001/02 and compared the results to the students' self assessment. The curves clearly demonstrate the workload of both students and the lecturer, as well as the type of work they are occupied with (questionnaires, programming, …). Also, it was clearly visible that the number of postings of the lecturer followed those of the students by one or two days, thus indicating that the lecturer often responded to student postings.

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