Web Based Online-Learning in Technically Equipped and Mobile Student Societies: A Case Study

Karin Anna Hummel, Helmut Hlavacs, Horst Weissenböck

Institute for Computer Science and Business Informatics
University of Vienna

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Abstract:

The availability of sophisticated mobile devices including notebooks and handhelds and standardized wireless communication techniques like IEEE 802.11b, Bluetooth or GSM/GPRS enable students to access learning environments from anywhere, independent of their location, individual movement and equipment. Focusing on the advantages for University students now possible, we have created an e-learning platform designed for enhancing courses to allow guided discussions, to access information and communicate anytime, anywhere and from arbitrary device types. Furthermore the platform supports team activities and offers additional services like personal status information and a barometer for student satisfaction. In this paper we present an evaluation of the usefulness of our online learning platform.

1 Introduction

In June 2001 the EU average of connected households amounted to 36,1%, in December 2001 the number increased to 37,7 % where the same number for Austria was 47,2% [12]. In contrast to former times of computer science education, it is now reasonable to assume that students of business informatics – our target group – are living in households connected to the Internet. With increasing bandwidth and decreasing costs, being connected while roaming using *GPRS, W-LAN hot spots* or in future *UMTS*, students may soon be connected anywhere and anytime. On the other hand, a significant number of students join – and will join – University lectures expecting high quality education, but University resources are limited.
To stay abreast of the socio-technical changes and to improve the quality of lectures for a great amount of students, we are expecting Web based online-learning platforms to be the next step in University education. Enhanced provisioning of learning material combined with tutored learning (e.g. by Web discussions) enables new and efficient ways to support individual students and collaborative student groups.
In this paper we describe a new e-learning platform aimed at showing how technically equipped business informatics students profit from a Web based learning infrastructure. We also report on the gained insight in the way the students use an online-learning platform, which was collected by evaluating the students' feedback. Furthermore, we point out some essential challenges for m-learning online platforms.
This paper is organized as follows: Section 2 gives an introduction to the students' learning behavior, their requirements and the enabling technologies for ubiquitous access to online-learning platforms, while section 3 introduces the design issues and the architecture of the

developed online-learning platform in detail. We finish the paper with a description and analysis of the students' feedback after using the learning platform in winter term 2001/02 at the *University of Vienna* and conclude with final remarks.

2 Trends in Distance Learning

The research done in the area of e-learning is widespread and very important. Multimedia enriched representations of teaching material, simulators and self-testing via multiple choice tests are very usable for self-study, but very costly while creating. The use of the Internet and its services as a basic network and distributed system offers nowadays a multitude of possibilities to retrieve information and to communicate with others, two important aspects of learning.

We think that communication and discussion-based learning approaches should be supported by a flexible learning environment and will be most successful when using the WWW (i.e. Web browsers at the client side) as basic technology – especially for University lectures.

2.1 Student's Behavior and Implications for Distance Learning Approaches

In the past years we discovered some changes in the behavior and the requirements of our students. The typical business informatics student is technically equipped and already working as a programmer, project manager or technical staff. This student relies on a flexible way of attending courses and has the ability to use his or her (mobile) computing and communication devices. The student shows up at the computer laboratory only in case of obligatory sessions or problems that cannot be solved via communication technologies like e-mail.

In order to fulfill the requirements of the students, we think the known pedagogical concepts concerning individual learning, tutored learning and group learning are to be supported by *distance learning* environments by content provisioning – enriched with multimedia and testing [13], by synchronous and asynchronous communication facilities between tutor or instructor and students, namely chat, forum and e-mail.

Requirements special for collaborative distance learning environments [14] are a participatory environment where horizontal collaboration between students is encouraged, a possibility for individual self-reflection and openness of the environment. Since learning is a social process, students will profit from supporting technologies for social interactions like expressing emotions, taking roles or allowing feedback, which transcends direct communication. In addition we think that feedback, guidance and motivation by instructors *just-in-time* and a clear insight to the current status (i.e. marks already gained) are important for the success of a distance learning environment.

Since society and students become more and more mobile, the type and kind of a learning session varies from the known "at home" scenario to the new "roaming" scenario, where the student usually is less concentrated, the mobile network is less reliable, data transfer rates are lower and communication costs are higher. Mobile learning sessions are characterized by short interactions (e.g. asking a questing in a chat room), quick information retrieval (e.g. looking up the next meeting date in a physical or virtual class) and working off-line connecting just for uploads from time to time. Here, students rely on enabling mobile technologies and decreasing costs.

2.2 Mobile Computing and Mobile Communication

In the last ten years mobile computing and communications has undergone a tremendous development. Ongoing miniaturization of electrical circuits has enabled the creation of small, portable devices holding long lasting energy sources. Standardization of wireless communication and the use of open operating systems have yielded a variety of portable computers being able to run a large number of software and being able to communicate with each other by just putting them close enough together or to a network access point. Portable computing initially was started by lightweight personal computers (PCs) running a standard operating system like Windows and being attached to an LCD screen, so-called *laptops* or *notebooks*. *Subnotebooks* again reduced the weight and size or portables, the smallest so far holding a nine inch screen and weighing about 1 kg (e.g. Sony Vaio PCG-C1MGP). However, further miniaturization still limits the number of available resources and impedes the use of standard Windows as a common base. *Portable digital assistants* (PDAs) thus use different operating systems requiring less resources, amongst them Palm OS, EPOC, special Linux versions, or Pocket PC. This shift of course also limits the number of usable (and interoperable) software, although for each of these systems already a large number of software packages exist. Java as a platform independent language has not yet been able to replace software specially compiled and tuned for a specific platform, being also restricted by low resource PDAs.

Generally, modern portables are already able to use one or several wireless communication standards. Wireless communication may either use a fixed network structure or may be created ad hoc. Networks using a fixed network structure may be run by a public company or privately. Public network structures are often either cell based, i.e., the covered area is divided into cells, or offer access at certain points only like internet cafes, here mainly using *wireless LAN* (WLAN) standards, a sort of “wireless Ethernet”.

Public cellular networks have been established since the 1980s, starting with the first generation mobile telephony (1G), being analogue only. In the 1990s, the generations 2G (GSM) and 2.5G (GPRS, EDGE) provided digital telephony and low and medium bitrate Internet access, still severely limiting possible mobile multimedia applications. Future generations of public cellular wireless networks however will demand much higher bitrates [3], i.e., 3G at 144 Kb/s mobile and 2 Mb/s static, 4G at 2 Mb/s mobile and 10-600 Mb/s static, and 5G at 100 Mb/s mobile and 600- Mb/s static (Figure 1).

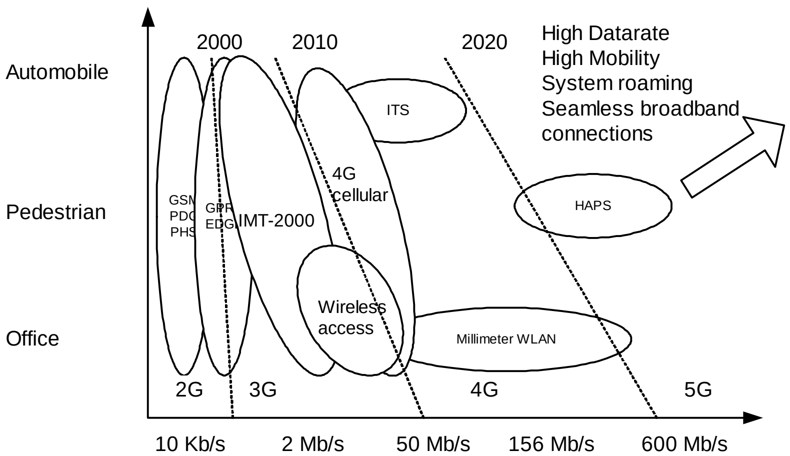

Figure 1: Wireless bitrate forecast.

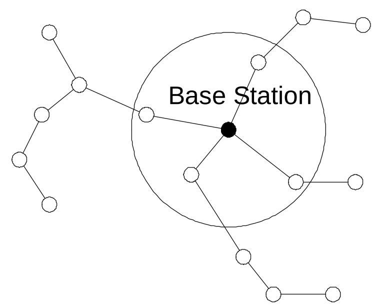

Figure 2: Cellular and ad-hoc networking.

In cellular networks, terminals located in a specific cell communicate with the cell *base station*, as illustrated for instance by the nodes in the large circle shown in Figure 2 [1], realized so far mainly by terrestrial antennas, and less successfully by *low earth orbit* (LEO) satellites. Future cellular networks though may rely on new access techniques and future mobile devices will have to automatically select the best possible network access from a wide spectrum of different systems (*system roaming*), a choice being based on aspects like available bitrate and connection quality, access costs, terminal abilities and established provider contracts.
In WLAN systems such as IEEE 802.11b [7], HiperLAN/1 [9] or HiperLAN/2 [5], network access is often granted by *access points*, being similar to the cellular base stations. Another possibility is given by ad-hoc networks (Figure 2 nodes outside the large circle), as for instance is given by Bluetooth [6]. Here terminals communicate only with neighboring terminals and no central access point is necessary.
Mobile communication is inherently unreliable and may face severe problems [2]: sudden loss of connection, relatively low bandwidth and high bandwidth variability, heterogeneous systems and devices, possible security risks due to radio communication, low power supply, weak computation power and small storage capacity of the portable devices. Software architectures for mobile devices must take them into account in order to prevent sudden loss of *quality of service* (QoS) or data loss. In such a case the work of students communicating with m-learning platforms may be severely endangered, and the students may soon loose their initial zeal and thus lower efficacy of the m-learning platform.
Also, future networks will provide *location based services* for their customers, i.e., services which depend on the device location and capacity. Examples include an adapting map of a University campus, information about equipment when entering a lab etc.
The scenarios described above already foresee the high mobility of future end users. In the concept of *nomadic computing*, such future users of mobile devices are seen as nomads without a fixed home base providing network access to them. Instead, the modern nomad moves from access point to access point, each providing access to the Internet or personal data. *Ubiquitous computing* extends the view of nomadic computing [16]. Here, the user is surrounded by an invisible computing environment without noticing it. Instead, the user interacts only with simple PDAs, hiding the complexity of the environment. Such a system relies on the automatic *discovery of services* offered by the environment to the portable device. This is often achieved on a client/server based approach, like the lookup service in JINI, the broker service in Salutation [8] or the spontaneous discovery service using the abstraction of User Agents (clients), Service Agents (services) and Directory Agents.
Furthermore, users of different environments may expect different system behavior, the system should adapt to different surroundings and situations. This notion of a*wareness* is seen in the dimensions of *location*, *time* or *situation* (e.g. attending a meeting, provisioning of information about colleagues depending on the spatial proximity, mood awareness, filtering of information when being tired or at home). Here, context information about the specific situation alters offered services and adapts automatically to the user's needs. Examples include a blocking of network connection during a test (in order to prevent students from cheating), location of other students or tutors in charge of a lab (but only during the operating hours of the lab), automatic check in at a conference, automatic presentation of dynamic content at a conference like the next sessions etc.

2.3 M-Learning

Generally e-learning is based on the use of technologies supporting learning. Introducing this idea to mobile learners means to use, research and evaluate the adaptation of e-learning approaches to a mobile infrastructure (devices and networks). Being mobile enables the application of learning scenarios to a multitude of new situations like *just-in-time* learning at work or autonomous *self-directed* or *tutored* lectures while traveling. *Life-long learning* and *training on-the-job* are supported in a ubiquitous way. Therefore, mobility itself will influence the way of learning fostering the utilization of small free time slices for learning and attending lectures.

It is expected that the concept for a lecture supporting m-learning will consider smaller learning units and will be aware of the learners' situation and place – an application scenario for ambient computing. M-learning consisting of mobile online sessions will not replace traditional e-learning online sessions completely because of their limitations due to concentration and time.

From a technology point of view, there are still some limitations for mobile learners. First, anytime and anywhere access to the Internet has to be provided by the network and the device (see Section 2.2). Using a wireless network connection often means significant additional costs, which will affect the success of a online-learning platform for mobile students. Connection loss, working offline and roaming between networks supporting different QoS and bandwidths has to be masked by the application and the limited resources of the device (like processor speed) may lead to runtime adaptation of the applications (e.g. the *Java* applets used). Furthermore, Web browsers running on a PDA differ from those running on notebooks. Mobile scenarios require a clear separation of content and presentation, where *XML* is a means for providing a such a clear and open separation.

3 The Online-Learning Platform

We tried several of the existing online-learning platforms before starting the development of our own environment. Some of the approaches are convincing, but show some major drawbacks for our concerns. For example, WebCT [15] demands a considerable administrative overhead and shows lacks of additional functionality and adaptability. It does not justify buying a platform designed for a multitude of students and lectures, if we aim at just one lecture. Other platforms like the free BlackBoard [17] version are not usable for us, because we do not want to keep the students' data on an external server.

3.1 Course Description, Motivation and User Interface

In order to choose a University lecture characterized by a multitude of different teaching methods, we decided to analyze and adapt an established laboratory course about distributed systems at the *Institute for Computer Science and Business Informatics* of the *University of Vienna*. The structure of the course follows a top-down approach based on constructivism learning theory in computer science education [18] first discussing the theory of distributed systems and implementing a client/server application with *Java/RMI* in teams of four students afterwards.

The educational methods used are a few presentations in class (for introducing the lecture itself and programming with *Java/RMI*), discussions based on a questionnaire about the theory of distributed systems, where students may gain additional scores for there final course grade, a test and the tutored software development of a distributed client/server application. Depending on the knowledge and preferences of the students, the programming part may be primarily done in a autodidactic way, by learning from group members or taking the assistance of the lecturer (both virtually and physically at the laboratory). In contrast to a reading lecture, our lecture swaps out the input phase almost entirely. The information needed to attend the theory discussions is either provided by the accompanying reading lecture or by articles which have to be read.

The goals of introducing an online-learning platform were to improve the quality of discussions, to emphasize coaching by different paradigms of communication, to increase the students' autonomy and self-control and to encourage group work. Figure 3 shows the correlation between the different parts of the laboratory course, the used learning and teaching techniques and the components of the online-learning platform, which support the students' work.

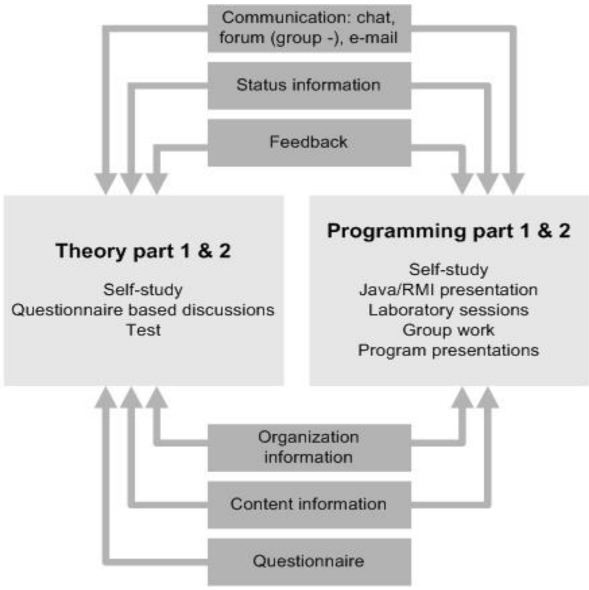

Figure 3: Work phases of the lecture and platform components.

In detail, the lecture starts with a theory part, where two questionnaires are discussed between the students and the lecturer. To evaluate the students' knowledge, a test takes place afterwards. We decided not to use any distance learning technology for this test because of the difficulties in finding out students' fraud attempts. The next step of the course is the implementation of a simple version of a distributed program and to show the program to the lecturer. This simple program is improved and enhanced to build a client/server application and presented to the lecturer at the end of the semester. During the phases of implementation the students may also show up at the laboratory and ask the lecturer (or tutor) personally or use the communication facilities of the learning platform.

Figure 4 - Figure 7 show screen shots of the online-learning platform's user interface which has been slightly adapted for the (English) reader. The menu bar on the right side shows the items corresponding to the components of the platform. *Organizational (items Schedule, Contact)* and *content information (item Work)* provides basic knowledge about the course organization and learning material like tutorials and papers and supports all steps of the lecture. Figure 4 shows a clipping of the online-questionnaire, which is part of the platform's *Work* section.

Furthermore, synchronous and asynchronous communication can be used by the students whenever and wherever they want. Synchronous communication is supported via a *chat room,* where once a week a fixed chat hour is reserved for talking with the lecturer. An *open forum (item Forum*) and a *forum per group* (*item Group,* Figure 5) is set up for students' asynchronous contributions, which can be tagged with emoticons. To give the students a mean for expressing own focus and subjects they may arbitrarily add a forum with a new topic in the open forum section.

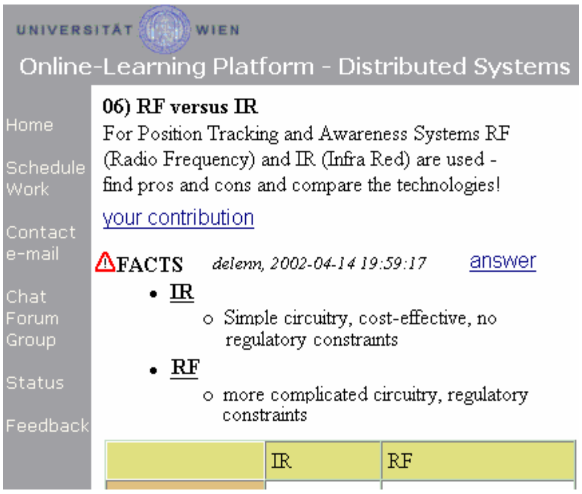

Figure 4: User interface online-questionnaire.

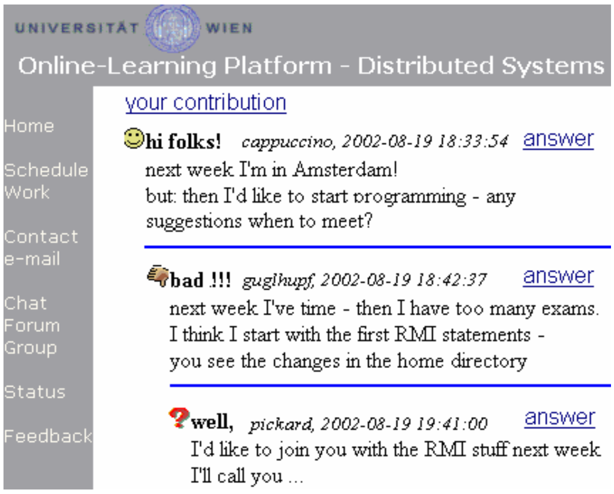

Figure 5: User interface group forum.

The *status information* (*item Status*, Figure 6) module shows the points already gained in every part of the course, while the *feedback* module (*item Feedback*, Figure 7) offers the possibility to give a brief insight in the students' contentment with the lecture. For the online-questionnaire, feedback, status and communication issues, the students have to login to the system. To provide anonymity to a convenient degree nick names are used for student accounts instead of the students' names or IDs.
The *administration* of the platform is done by the lecturer using an administrator account and a special entry site. It is possible to create new courses, administrate students' data and administrate parts of the lecture (e.g. changing the questionnaires status from being open to closed for contributions).

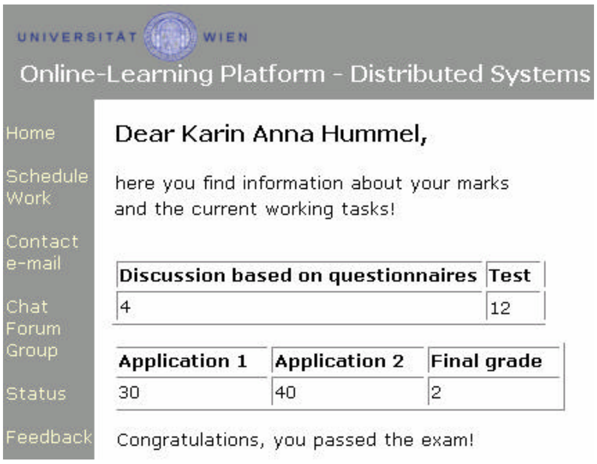

Figure 6: User interface status information.

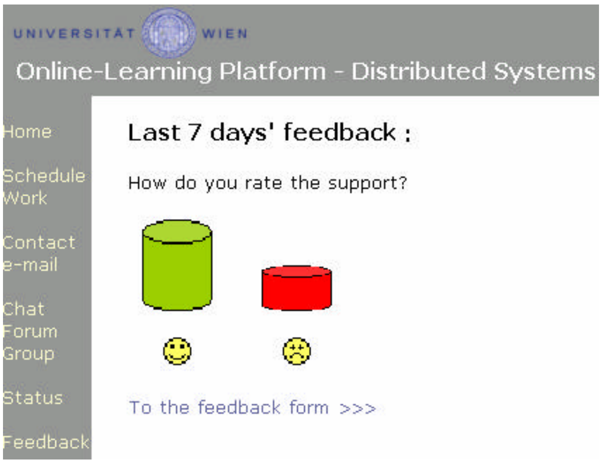

Figure 7: User interface feedback.

3.2 Design Issues and Architecture

The design of our software modules follows the principle of keeping the platform simple, clear and easy to use via the Internet while using devices with different capacities (display, computing power, etc.). In order to fulfill this requirement our platform is accessible by a Java enabled Web browser (we tested with *Netscape*, *Conqueror* and the *Internet Explorer*). Due to security reasons we also need the support of an *SSH* – client to allow login and data transfer access to our computer network where the students' home directories are situated. Figure 8 shows the server and interface architecture of the online learning platform.

From a software architecture point of view, the content should be separated from the presentation, so we decided to build most of the Web pages dynamically accessing the data from a *MySQL* database. For database access we decided to use *Java* classes (Java framework) and the integrated *JDBC/ODBC bridge*. *Java Server Pages* (*JSP* [11]) are used to produce the presentation, as a container server for the servlets *Jakarta Tomcat* is used. Concurrent access of multiple of students is supported without interference by the means of the Java framework and the database access utilities. For session management, cookies (or URL rewriting) were used to provide a convenient personalized access for the students. As a chat program we integrated the already existing *VisualChat* [10] from the University of Linz.

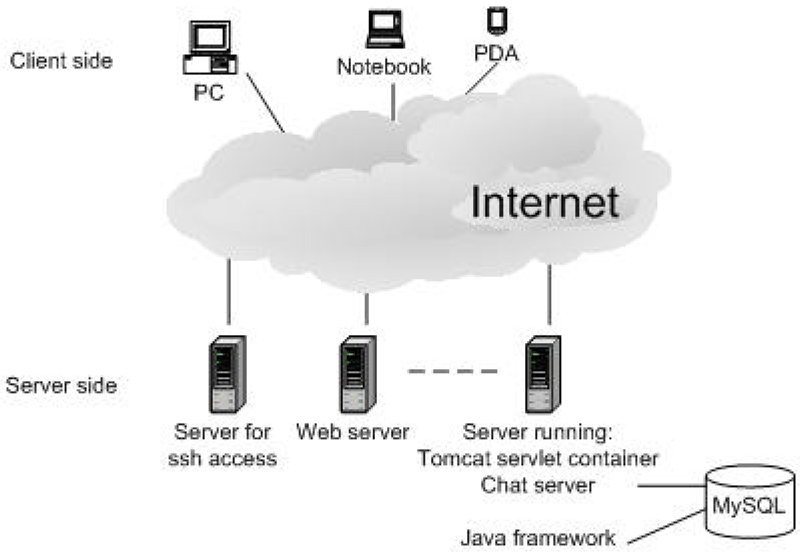

Figure 8: Online-learning environment architecture.

4 Experiences and Students' Feedback

We first introduced the online-learning platform in winter term 2001/02, where about 64 students attended the course and 54 answered the feedback questionnaire at the end of the lecture.
The used technology was very stable, only once - within a period of 4 month - we had to restart the servers manually. Some browser problems occurred (using *Opera*), but could not be reconstructed – neither by us, nor by other students. The session timeout used for the login sessions was too low using 15 minutes – so we decided to increase it to 30 minutes. We tested and successfully used our platform using a PDA (COMPAQ iPAQ H3600), but the framing of our Web sites and the display of the PDA were not convincing.

4.1 Observed Students' and Lecturers' Behavior

In accordance to our design goals we expect the students to simply like working with our platform because it offers flexibility in time and space. Our experiences show that the students are highly motivated to work with the online-learning platform, as well as the lecturer. During the theory part the student online times achieve a global peek. After a rather "autistic" starting phase characterized by students' contributions ignoring statements already posted before, a vivid discussion arises. Furthermore, meta-information like how to structure the contributions using *HTML* tags is spread very quickly among the students.

Because all contributions demand accurate and timely answers, this phase is very time-consuming for the lecturer.
In contrast to the first part, the students do not use the platform that much in the programming part. Now the lecturer's task is mainly to keep the students participating while asking questions and giving hints to keep the forum alive. The students work in groups at home and do not show up at the laboratory too often. Questions are answered both by students and the lecturer in the forum and during the chat hours.
In general, students use asynchronous communication (forum, e-mail) more frequently than synchronous communication. The chat room is primarily used for precise and short questions and answers, during the programming phase it is sometimes used as a kind of online programming support.
Status information and the possibility to give a brief feedback to the lecturer are frequently used, feedback is given both when feeling well and badly advised.
We are a little bit surprised that the group forum is not used as much as expected (see Section 4.2).

4.2 Feedback Inquiry

Figure 9 shows the results of the students interrogation at the end of the semester graphically, the numbers detailed in Table 1 represent the amount of answers given in each category.
We first want to know about the students' satisfaction with the platform in *General*. Most of the students are satisfied to a high degree (because of the increased flexibility and accurate and timely information the platform offered), two students complain about the lack of personal contact to the lecturer.
The figures in section *Group* show no high estimation of the group forum, which we thought of being the main meeting place for the group in the programming phase of the lecture. We consider the students have already well established communication paths (e-mail, physical meetings, etc.) and the forum for each group is no real benefit.
The information about the current status is of great interest as well as additional information about the work next to do. Given the possibility to give a simple and short feedback on the current affection related to the course is also positively approved (*Status/feedback*).
Asking about the satisfaction with the means to contact the lecturer shows that most of the students do not miss the lack of personal contact. Chat, forum, e-mail and the possibility to come to the laboratory seem to be enough satisfying (*Contact*). The communication restricted to the means mentioned above is not that rated that high. The reason may be the "lazy forum period" while implementing the client/server application and the frustration about the chat room, where no critical mass shows up, except for the lecturer online hours (*Communication*).
The access and quality of the documents, manuals and papers provided are rated positively (*Documents*).
We are very glad to see that our main pedagogical concept is accepted, namely to give a number of about 60 students the possibility to learn while discussing distributed computing technologies with their colleagues and the lecturer (*Questionnaire*).
Most of the students access the learning platform solely from home (*At home)*, some also from their jobs (*At work*) and some also from the University campus (*At campus*). This implicates that our business informatics students are not yet the mobile students depicted in the sections before, who access the online-learning platform from wherever they are.
However, they use the platform quite frequently, most of the students rate their access between 5 to 15 times per week (*Frequency of access*).

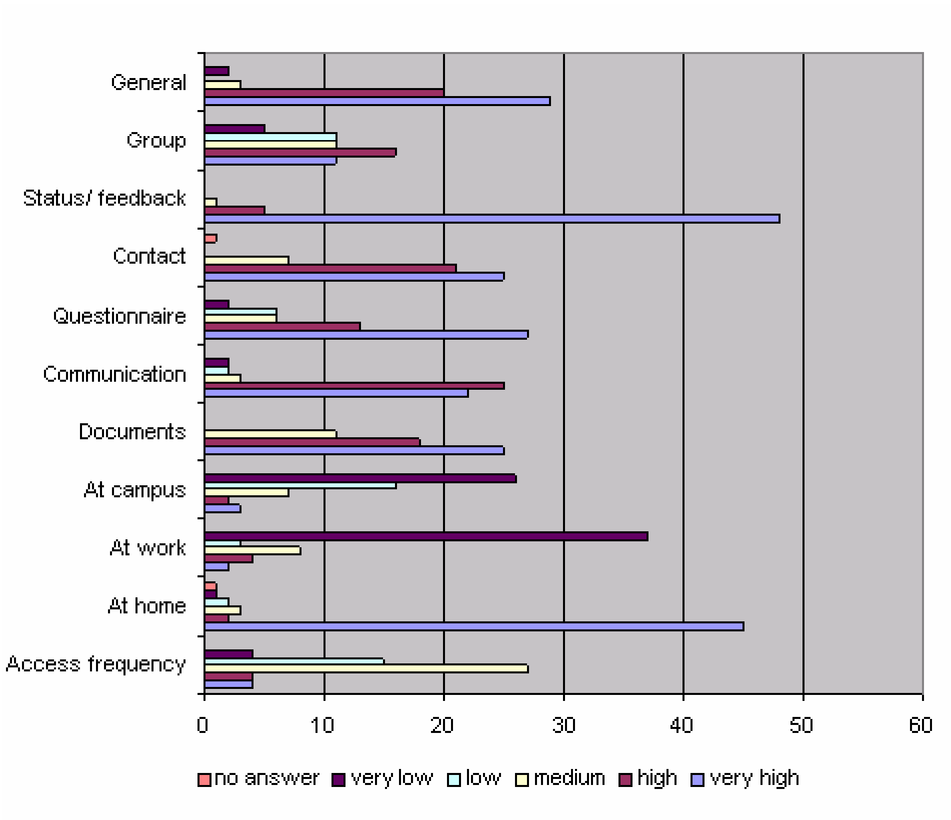

Figure 9: Graphics of students' rating of the online-learning platform.

	General	Group	Status/ feedback	Con-tact	Question-naire	Comm.	Docu-ments	At campus	At work	At home	Access frequ.
no answer	0	0	0	1	0	0	0	0	0	1	0
very low	2	5	0	0	2	2	0	26	37	1	4
low	0	11	0	0	6	2	0	16	3	2	15
med.	3	11	1	7	6	3	11	7	8	3	27
high	20	16	5	21	13	25	18	2	4	2	4
very high	29	11	48	25	27	22	25	3	2	45	4

Table 1: Numbers of students' rating of the online-learning platform.

5 Conclusion

In this paper we motivate the introduction of Web based online-learning platforms for University lectures by drawing a picture of current and future technologies including networks and devices which will provide access to the Internet anytime and anywhere. Lectures will need to be built up of small units and support different kinds of sessions to allow attendance of mobile students in a situation aware way.

The implemented online-learning platform presents an approach on the basis of constructivism and our believe in group work and learning by discussing. The platform supports guided discussions on theory and provides manuals and tutorials for the programming part of the lectures. Asynchronous and synchronous communication is fostered by a general open forum, by a group forum for each group consisting of four students and a chat room with a fix lecturer chat-hour once a week. The students have accurate access to their status and may give a short feedback about their satisfaction. The online-learning

platform is usable via any Java enabled Web browser and relies technically on the use of *HTML*, *JSP*, Java framework classes, *Java Applets*, the *MySQL* database and the *Tomcat* Web server. Mobile users (using e.g. PDAs being connected via WLAN or a GPRS enabled mobile phone) can also access our Web based approach.
The evaluation based on a questionnaire survey among our students of the laboratory lecture held in winter term 2001/02 shows that the students generally approve the platform. Self-directed learning and discussion-based learning is successfully supported by online-documents and the online-questionnaire. The means to contact the lecturer and other students (e-mail, forum, chat) are satisfying, however, concerns arouse among some students who prefer personal contact. The group forum intended to support the collaborating programming teams was not commonly used. Generally, asynchronous communication is preferred because of the grade of independence in time. Accessing status information and giving feedback are much valued. As a consequence, most of the students access the platform frequently (5 to 15 times a week) - logging in from at home.

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Author(s):

Karin Anna Hummel, Dipl. Ing.
Institute for Computer Science and Business Informatics
University of Vienna
A-1080 Wien, Lenaugasse 2/8
karin@ani.univie.ac.at

Helmut Hlavacs, Dr. techn.
Institute for Computer Science and Business Informatics
University of Vienna
A-1080 Wien, Lenaugasse 2/8
helmut.hlavacs@univie.ac.at

Horst Weissenböck, Mag.
Institute for Computer Science and Business Informatics
University of Vienna
A-1080 Wien, Lenaugasse 2/8
a9100752@unet.univie.ac.at