

# Remote versus Traditional Learning in a Computer Networks Laboratory

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**KEYWORDS:** remote laboratory, didactical issues, cognitive learning

**Abstract** Didactic aspects of Internet-based courses are somewhat different from the didactic aspects of traditional university courses. In this paper the didactical as well as the technical differences between the traditional and the on-line version of a computer networks laboratory course are analyzed, and conclusions for further improvements are discussed. Although the first experimental test for the on-line version was only done with a small number of students and for one module of the course, the received feedback gives an optimistic impression for this kind of curriculum supplement.

## 1 Introduction

There is a high pressure for universities to offer interactive on-line courses on the Internet. One reason for this pressure originates in the Internet hype of the recent years. What remains of this hype is the prevailing opinion that educational establishments not offering such courses are somewhat archaic. Unfortunately, this pressure lets most course designers forget what students really like and need to get involved with electronic courses. Course designers need a solid background in the course topic itself as well as in didactics. Nowadays, most courses are designed and implemented by conventional tutors that lack experience with on-line didactics. Therefore, one major perception is that even state of the art courses could be developed much further. Many interesting and useful tools are still under development and far away from being widely deployed.

There are mainly two approaches for programming an interesting course. One is the analytic way, where didactic specialists analyze the task to be done and based on their conclusions a course is then implemented. The other way is the empiric one. There, traditional learning forms are adapted and developed further into Internet-based courses. The course described hereafter originally started with the empiric approach. Soon after the start, it became obvious that analytical work is absolutely necessary too. Both approaches got more and more mixed-up. The gained didactical skills encouraged us for learning more about the analytical way.

This article describes the feedback and experiences made with a traditional computer networks laboratory that was developed towards an Internet-based computer networks laboratory. The test user group consisted of eleven male and one female third year computer science students.

In the next chapter, topic related work is shortly presented. Then, the traditional computer networks laboratory and the conclusions of an earlier run are presented. In chapter 4, the Internet-based course is explained in more detail. Chapter 5 discusses the students' feedback and the tutors experience made with the Internet-based module. The last chapter concludes and gives an outlook on the future work.

The tested course module is called "IP Security" and is part of the Virtual Internet and Telecommunications Laboratory of Switzerland (VITELS). VITELS is one of several projects within the Swiss Virtual Campus (SVC) program funded by the Swiss ministry of education and science.

In spring 2002, a test group performed the Internet-based version of one module of the traditional computer networks laboratory. It was a first test with twelve students of University of Bern. It allows comparing the behavior of students that made the traditional course in 2001 with the students that made five traditional modules and one Internet-based module in spring 2002. Further, it allows gaining valuable experience to be used for improving the course and preparing the next run in an upcoming semester. The next run will be done with about 30-50 Swiss students of the French and German speaking parts. Table 1 shows the different runs, the location and the course form, i.e. traditional or Internet-based.

Runs	Location	Course Type
Traditional Laboratory 2001	University, in the Lab	Traditional
First Test Run Spring 2002	5 traditional modules in the Lab, 1 module anywhere	Traditional and Internet-based
Second Test Run Fall 2002 (planned)	Anywhere	Internet-based

Table 1: Runs of the computer network laboratory

## 2 Related Work

The VITELS project is something new to the Internet course community. It is one of the few projects, which include original third party network equipment such as configurable routers and servers. [Mentor Technologies]' vLab (virtual laboratory) offers laboratory modules with real network hardware (routers and switches) and scheduling for user access. But vLab is a commercial project for well paying clients and only few technical details about their courses are available. An architectural difference is that their modules are not locally distributed. In the Internet demonstration, they worked with remote desktops and voice conferencing tools. [Nano-World], another SVC-project will connect electron microscopes to the course architecture developed by us. The didactical approach is quite similar to the VITELS course. Both projects now work together in the ongoing development of the course architecture and maintain an active exchange of didactical and technical knowledge.

An excellent remote course, called "Vom Basiswissen zum Netzmanagement" is offered by [TU Chemnitz]. A big difference to our approach lies in the authentication and authorization procedures. In TU Chemnitz' course entire classes get access to one specific laboratory during a specified time period, whereas we only open modules to pre-registered students that have booked the respective laboratory on-line.

[Patel et al. 1998+2000] research in the field of cognitive skills and intelligent tutoring for life-long-learning. In their paper about the design, development and implementation of Intelligent Tutoring Tools (ITT) developed by the Byzantium project, they conclude that a very high proportion of learners tends to have problems with numeric disciplines and can greatly benefit from the cognitive apprenticeship approach of the Byzantium ITT. For the VITELS project, this means that the learning process of an individual should not be limited too much. The student must have more than one way through the course and to the learning goals. [Collazos et al. 2002] conclude that the gender difference is a factor, which influences the process of collaborative activity within groups. [Heller et al. 1992a+b] showed that the size and composition of teams is very important for the success of the learning process. Yet, the team composition must be kept in mind for future tests with more than one female student such as in the spring 2002 test.

## 3 Traditional Laboratory Modules with Teamwork

In [Steinemann et al. 2002a], the advantages and disadvantages of a traditional networks laboratory course were analyzed and proposals for a transformation to the Internet were described. The traditional computer networks laboratory course consists of several modules (learning units or chapters) that are split into three sections: pre-laboratory, laboratory and post laboratory. In the pre-laboratory, students study subject matter-related theory and get a lot of pointers to additional resources such as web links, books, and papers. The section ends with a test that is evaluated and grants access to the next section. The time spent in the theory section should not exceed six hours for an average student. More time can be spent when knowledge gaps are discovered or the interest in the topic is deeper. The second section, the laboratory, is the most interesting of the three. Students come to the university and spend four hours as a team of two persons in

the laboratory. Just well prepared students can work through the laboratory section in only four hours. They have to solve tasks like configuring servers and routers with original network equipment. The whole course is built on trial-and-error learning within a team. Many students liked to spend more time than necessary in the laboratory as it often was the first time they could escape from theory and make hands-on experiences. With the gained knowledge and saved log files students proceed to the third section. The third section is the post laboratory and allows students to deepen the before learned subject matter. Tutors have the possibility to grade the performed work as students finish the post laboratory with a test.

For the completeness and understanding of the sequel to this article, a short summary of the student feedback and of the staff's impression about the IP Security module in the traditional laboratory course and the conclusion shall be given.

Preparation work is urgently needed for the students to successfully perform a practical exercise. It was discovered that most students did not prepare themselves sufficiently prior to the practical work. Those in particular had significant problems solving the exercise tasks within a reasonable time. The same students had to ask many questions to the tutors during the laboratory session. Other students had already forgotten the theory learned in the lecture during the two preceding years. Although all the students studied computer science, for many of them it was the first time they could set-up and work on real network servers and routers. Students were amazed about the opportunity to work on real network hardware and to leave theoretical studies for a short time. A final analysis showed that students especially liked hands-on work and that this is definitely a desired supplement to the study curricula. Students did not like the pre-laboratory. The theory should therefore be included in the trial-and-error process of the laboratory section. Unfortunately, the laboratory time had to be split in slots and one group could maximally occupy two time slots. As a consequence, students that skipped preparation and tried to integrate it in the practical trial-and-error section could not succeed within the estimated time. A resulting conclusion is the integration of interactive learning material in the theory section of the Internet-based course. Another is the supply of hints in the practical work section to prevent blockades in the laboratory session. Yet another conclusion was that only evaluated work stimulates studying.

The teams were limited to two students and the whole work was performed in the team. Only the preparative reading and learning was done independently. The computer science laboratory at University of Bern offers space for two teams, and other students work in the same room. This situation provoked many fruitful discussions about, but not only, the laboratory work. Students learned that teamwork leads faster to the goal, or in other words: altruism wins over egoism.

Many conclusions of the experiences made with the traditional networks laboratory found their way into the didactical concept of the Internet-based version of the course.

In the spring 2002 test run, students attended five traditional modules similar to the students in 2001 and one Internet-based module. The feedback of spring 2002 shows the same advantages and disadvantages of the traditional learning form as before in 2001.

#### **4 Internet-based Laboratory Module without Teamwork**

As the title already anticipates, a major difference between the traditional modules and the on-line module lies in the loss of teamwork. Especially in this first test run, where students have worked together in five traditional modules, students missed the trial-and-error experience made in teamwork in the Internet-based module. This abrupt change was intentionally, as it is important to get the feedback of both of the two extremes, the teamwork in the traditional laboratory and the isolated single person work in the on-line laboratory. In the next section, the implemented IP Security module shall be introduced.

The Internet-based version of the module IP security, differs significantly from the traditional one. The whole work is done in front of a remote computer screen. The whole set of resources is on-line available and, interactive course content such as animations, enrich the theory section. The tests are done on-line in the same manner as feedback and help is provided on-line. The most remarkable change lies in the remote laboratory work and especially in the complete loss of teamwork. Figure 1 shows the main differences concerning the location of work, teamwork, and the media used in the two course types.

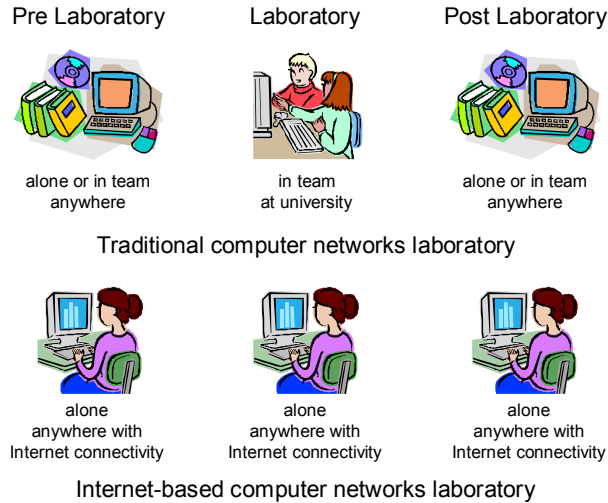


Figure 1: Places of learning activity

The technical aspects of the architecture behind the remote networks laboratory are described in [Steinemann et al. 2002b]. Figure 2 shows the simplified architecture behind the VITELS course. The three main components are outlined: the students that access the course, the laboratory module at the resource owner site, and the course management system, which performs authentication, authorization, accounting, and also scheduling functions.

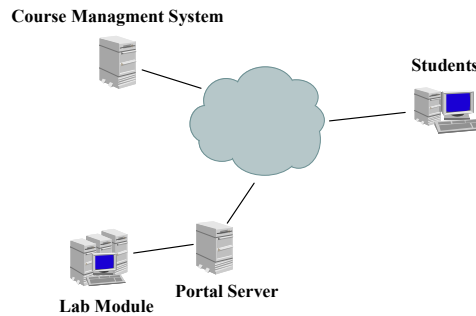


Figure 2: VITELS course architecture

#### 4.1 Snapshots of the Internet-based Laboratory Module

In the Internet-based course, students are lead through the modules by a course platform. In our case, the course platform is WebCT. Additionally, students open browser windows with secure shell applets to each of the laboratory devices. This allows a guided learning without limitations concerning the hardware configuration. The course language is English.

The module begins with an extended chapter of contents that is named storyboard. Figure 3 shows the storyboard, indicating the estimated times a student has to spend in each section. The storyboard provides the student with information about the timely progress in the module.

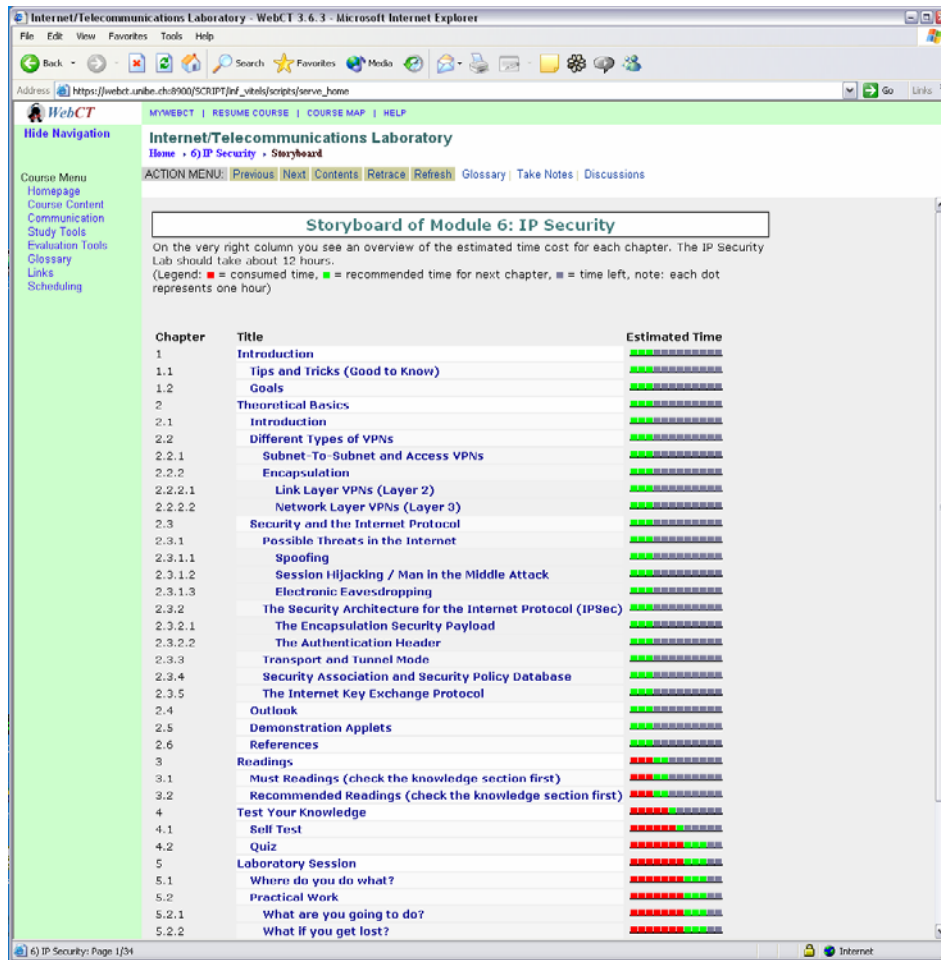


Figure 3: Storyboard indicating the estimated time in each section

Students first work through the pre-laboratory section, where mandatory theory is located. The section is enriched with figures, images, and interactive Java applets. Reading material can be selected with the help of self test questions and preparation time thereby reduced. Wrong answers provide a pointer to a recommended reading source. The section is finished with a test.

Before students proceed to the laboratory, they have to book a time slot. Figure 4 shows a screen shot of the time table, provided by the VITELS course reservation system. Students can see if a slot is free, occupied or if they have already reserved a slot. This limited information release is due to data protection laws. Unfortunately, this limits the exchange of slots among students, as they don't know who booked the other slots.

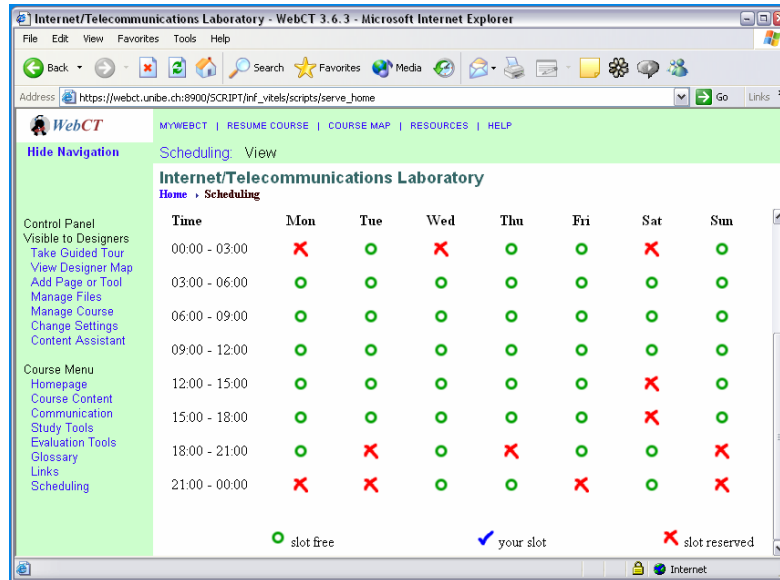


Figure 4: Work times in the first week of the laboratory

In the laboratory work section, students open direct connections to network routers and hosts, configure routers and hosts and set-up a virtual private network connection. At critical points, where students could get into trouble, the course provides hints. In this manner, students don't get blocked and can proceed through the laboratory session.

The post laboratory section consists of a quiz, which is timely unlimited. Students need the results from the preceding section to solve exercises in the quiz. The quiz faces students once more with the subject matter of the theory section and the laboratory work. It also allows tutors to evaluate the performed work.

#### 4.2 Students' Feedback

Students' feedback mainly depends on the origin, former education, and gender of the testers. Twelve students participated in the spring 2002 test. Nine male and one female student returned the feedback form at the end of the test run. All of the testers were computer science students and had already finished their basic studies. The small group of testers allowed an intensive interaction and feedback collection by the tutors.

First of all, it was surprisingly to see that even computer science students experienced troubles caused by the different browsers and operating systems.

Most students prepared the laboratory at home and only few students worked at university.

During the test, students got response by Email or telephone from a tutor within zero to six hours in case of problems. The discussion board was revised on a regular basis of about four times a day. Students appreciated the short response times.

There was negative feedback concerning the hardly understandable user guidance of the course platform. The course platform earned negative feedback not only because of the non-intuitive user guidance but also because it uses a lot of Java scripts. Java scripts provoked a lot of errors in the different browsers and versions.

As expected, the non-existence of teamwork throughout the Internet-based module resulted in many complaints. Many students wanted to have more interactive content and more practice-related examples in the theory section. One student had problems finding specific parts of the theory by means of the table of contents. The pre-laboratory quiz was timely limited. One student wanted to have the opportunity for breaks during the pre-laboratory quiz. Many students liked to print-out the theory section and there was a lot of negative feedback until the theory was offered as a downloadable and printable file.

The high availability of the laboratory equipment and the fast download speed of the course material were positively mentioned several times.

Students liked the integration of different types of interactive technology and the resulting course, such as with interactive Java applets. Students liked to work on real network hardware, to configure routers, to do hands-on work. The experience with real network hardware was frequently mentioned as very fascinating. The framework of the course platform that leads through the course and additional windows with connections to the hardware imparted the impression of a guided working with a high degree of freedom. Students liked to solve problems in a trial-and-error process as they are convinced that knowledge gained in this way stays in mind for a longer time. The quizzes consisted of multiple choice and essay questions. Students liked the mix but preferred multiple choice questions. It was often mentioned that the learning content was well adapted to the learning objectives. Students were thereby motivated to read through, and not to skip, the theory part. Students found that the course was comprehensive documented. This seemed to be very stimulating for the learning behavior. Most students liked the independence of time and place of work, although in the final discussion, one student complained about the expansion of work times into free times such as evenings and week-ends.

More external pointers to original Internet resources are on the wish list as students think the Internet should be integrated directly with all its abundant resources. From the tutor side of view, this provokes mixed feelings as it takes a lot of time to update Internet resources. Not only the whole literature should be downloadable and printable, the exercises and solutions as well should be downloadable and printable. One student missed a module résumé on one A4 page. Several students wanted the possibility to have secure file transfer protocol (sftp) for transferring dumps of the exercises instead of copy and paste the results.

## 5 Discussion

It is surprising that even experienced users like computer science students complain about technical problems. This is a circumstance that forces course developers to design courses as user friendly and simple as possible.

The disfavor students showed for the selected course platform may have several reasons. The course platform limits users to few actions and it is difficult to promote cognitive learning styles in this environment. Students have no possibility to take notes and write them directly into the text, such as they do when taking notes reading a paper copy. Figure 5 shows course platform's note function. The note function opens an additional browser window and lists the all the notes of the entire course on sheets per course page.

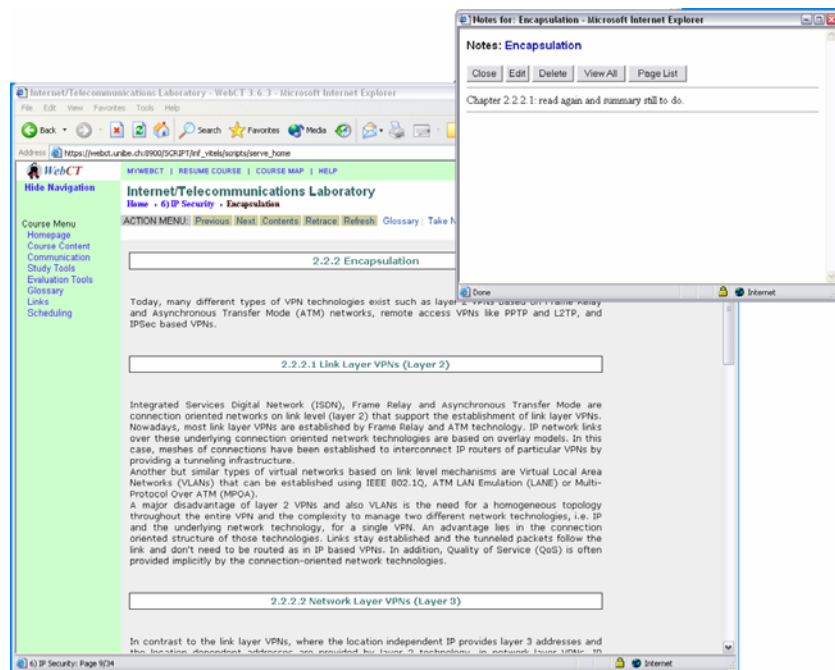


Figure 5: Notes tool in the selected course platform; additional window pops up with the notes.

A better example is the post-it style such as Acrobat Reader or Outlook offer. Figure 6 shows a photo composition of an Outlook note in a WebCT page.

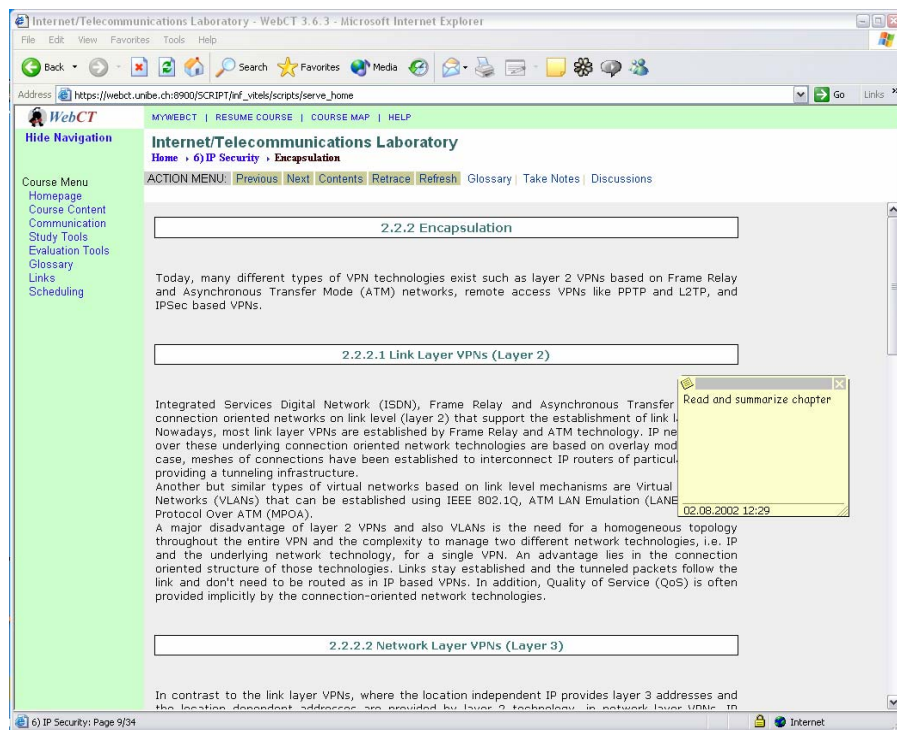


Figure 6: Notes taken with Acrobat or Outlook; notes can be placed in the text.

It is not possible to use markers in the selected course platform. This is a heavy disadvantage compared to paper copies. Students are used to notes and markers and even a next generation student will have to use both of them in his learning process. As the course platform is new for most of the students, it is well possible that they have not yet made the needed adaptation to this learning environment. Internet-based courses demand a high enrichment with interactive media. The feedback showed that it is still a long way to the desired level of interactivity in our course module, although students already liked the presented mixture of text and interaction.

The analysis of the time-table showed that a majority of students liked to work in the evening and on week-ends. Figure 4 shows the first week of three. As there were only twelve students, they were allowed to occupy more than one time slot. Figure 4 exemplarily shows that students like to work in the evening and on week-ends.

Students liked the information provided by the storyboard. This fact raises the question on how it is possible to provide more useful information to students throughout the course. An additional window that shows the remaining exercises, reading material and more could be a possible solution.

The quantity of the self test questions is still too low; an ideal number of about fifty questions with pointers to resources in case of wrong answers would be adequate for this twelve hours module.

Students need feedback to their questions. A discussion board helps to solve problems and involves eager students in the support process. But postings must be a part of the evaluation process and therefore be mandatory, else many student stay away from active participation. After each course cycle, important questions should be extracted and summarized in a frequently asked questions section. There must be a hotline that is available during the times the course is available; that means nothing else than 24/24 hours. It is still not yet evident, how this can be organized in future. Students expect a fast response in case of severe problems such as hardware failures. As a result of that, we suggest a help pyramid such as Figure 7 shows with the tutor on the top. Each step of the pyramid filters questions and finally only urgent question find



their way up to the tutor. The first step of our help pyramid is the frequently asked questions section. The second step is the discussion board. The third, Email support and the last telephone support by the tutor.

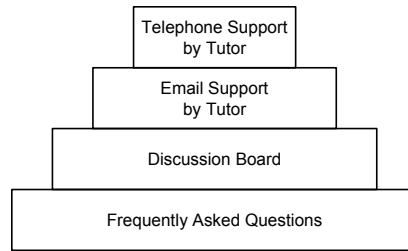


Figure 7: Help pyramid

Why students prefer teamwork to single work is not easily answered. It is out of doubt that team work is necessary in most areas of life and that teamwork simplifies learning processes. But it is obvious too, that teamwork is misused by free-riders. Universities have the task to accompany students throughout their studies. Free-riders are better involved in the studies if they are forced to make the tests and exercises alone. Another means by which free-riders are better involved is the generation of tests consisting of randomly generated quizzes with a big underlying questions base.

## 6 Conclusions and Outlook

On-line courses are a welcome supplement to traditional study curricula. Students need the contact with real tutors and real class mates as well as the contact with lecture rooms. Otherwise the community feeling gets lost and interest in studying decreases. None of our students could imagine studying only with Internet-based courses. It remains unanswered if future generations adapt other learning habits and will think different and maybe even prefer Internet-based courses. Nowadays it seems possible to offer interesting Internet-based courses. An advantage of such course is that they allow concentration on own competences when shared with partners. Thus the amount of students in the courses can be increased, and the work-load for tutors decreased. Expensive resources are operated at a higher capacity and money can be saved.

The next test is scheduled for fall 2002 with about 30 to 50 students. The above described conclusions should influence the course design and development until then. The feedback assessment must be improved and the didactical aspects of the course too. Specialists are required. Inter-university cooperation has been established with didactic specialist and SVC provides didactical support. More ahead, there are many improvements or enhancements to be done.

The course module IP Security is designed and implemented by Swiss German people. The course will be used by Swiss French people or even by an international audience. Different cultures have different learning styles. Probably, the course has to be adapted to other cultures. In any case, one enhancement that has to come soon is something like a virtual team market place, where students can anonymously look for team mates (due to data protection laws, students must remain anonymous). The importance of this component is even much higher if the course is used by students that don't know each other personally from real university courses.

For the next test cycle, teamwork must be added. Perhaps the teamwork will consist of two students sitting in front of the same PC during the laboratory work. On the wish list is a tool for application sharing among students. This could allow locally distributed students to work in a team, thereby giving the feeling of sitting together in the same room.

In the next years, audio and video applications should become common tools for normal Internet users. This is not only a problem of bandwidth as many people believe, it is also a problem of fast enough computers and the fact whether microphones or cameras are installed and accepted by the users. Then, a virtual classroom could be designed, where students meet and can make teamwork.

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