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Pharmasquare (*Pharma²*)

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Abstract: The project ***Pharmasquare (Pharma²)*** is based on the regular course 'Pharmaceutical Chemistry: Drug Effects on the Molecular Level' alternately presented in Zürich and Basel using the videoconferencing system Telepoly. The course is part of an open learning environment, which is currently complemented by distant learning facilities including a virtual learning environment. ***Pharma²*** receives financial support from the Swiss Virtual Campus, the ETHZ, and matching funds by the Universities of Basel and Neuchâtel. In its final form, the virtual learning environment will offer web-based training modules, a virtual laboratory, the adaptive self-assessment system ***PharmAskYou***, scripts of the Telepoly lectures including learning objectives, a glossary in pharmaceutical sciences, a news-platform, a discussion forum and the 'Question of the Week'.

Keywords: Blended learning approach · e-learning · *Pharma²* · Pharmaceutical chemistry · *PharmAskYou* · *Tetrodo* · Virtual laboratory · Virtual learning environment

1. e-Learning in Switzerland

Multimedia and information technologies increasingly conquer many aspects of our society, last but not least the sector of higher education, where they have triggered a fundamental change in the way teachers teach and students learn. e-Learning greatly benefits from technical developments such as Telepoly [1], a hightech synchronous videoconferencing system based on ATM, NET [2], the network for educational technology at the ETH-Zürich, LearnTechNet [3], the network for e-learning at the University of Basel and Ariadne [4], a research and technology development project pertaining to the 'Telematics for Education and Training' sector of the 4th Framework Program for R&D of the European Union.

In 1999, the Swiss Federal Government started the Swiss Virtual Campus – Impulse Program [5] with the aim to foster new learning technologies at Universities, the Federal Institutes of Technology and Universities of Applied Sciences. The main objectives are the improvement of the quality of the student's learning process, the strengthening of collaboration between higher education institutions and the development of high quality multilingual teaching materials and methods.

For the realization of this Swiss Virtual Campus – Impulse Program (2000–2003), 50 projects, which were selected by peer-review processes, were funded by the Swiss Federal Government. In addition, the participating universities had to guarantee matching funds. The projects supported by the Swiss Virtual Campus initiative cover courses in all major academic disciplines, *i.e.* art and humanities, medicine, engineering and information technology, physics and mathematics, business administration, economics, finance and law, environmental and life sciences. Since the governmental support will end by December 2003, the financial aspects in the subsequent maintenance phase (Consolidation-Program; 2004–2007) are being currently vividly discussed.

2. The Project *Pharmasquare (Pharma²)*

2.1. *History of the Project*

The knowledge base in biomedical and pharmaceutical sciences is growing with increasing velocity and the turnover of relevant information has been tremendously accelerated. This situation clearly demands the corresponding development of the teaching and learning environment. Since traditional methods are no longer meeting the requirements caused by this information overflow, the possibilities for fast interactive, point-to-point delivery of teaching and learning contents offered by information technologies are increasingly attractive. In addition, IT-based developments of interactive self-assessment and testing-tools will offer students suitable fostering as well as individual feedback concerning their knowledge level [6].

In 1998, the development of our new concept was initiated as a part of the Pharmaceutical Chemistry course offered to students of the 3rd and 4th year of the diploma course of Pharmaceutical Sciences at the University of Basel and the ETH Zürich. In the initial phase, lectures which are alternately presented by Prof. Gerd Folkers at the ETH Zürich and Prof. Beat Ernst at the University of Basel are transferred online to the other location by Telepoly [1]. This first step towards an innovative pharmaceutical

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chemistry curriculum merged partners from the two locations in one virtual learning environment. In a second step, the web-based virtual learning environment ***Pharma²*** [7] is currently accomplished in a collaborative effort of three partner institutions, namely the Universities of Basel and Neuchâtel and the ETH Zürich.

2.2. *The Web-based Virtual Learning Environment*

With the virtual learning environment the following goals should be achieved:

- Learning will be individualized, *i.e.* the students will have more time for individual learning according to their own time management and independently of their working place (asynchronous learning).
- The learning process will be optimized with simulation tools providing the student with deeper insight into complex matters.
- With its combination with Internet and its inherent linking, the virtual learning environment will provide a multidimensional library of texts and objects, which will be available according to the needs and preferences of the individual user.

The web-based virtual learning environment in its final form will consist of four parts (see Fig. 1), *i.e.*

- A **self-study environment** (web-based training modules, a virtual laboratory and the adaptive self-assessment system ***PharmAskYou***),
- A **communication platform** (a news-platform, a discussion forum and the 'Question of the Week', which is of topical interest to drug research and development),
- **Supplementary material** (scripts of the lectures including learning objectives, animations, videos and links to databases and suitable web-pages) and
- **Auxiliary material** (glossary in pharmaceutical sciences).

The users are undergraduate students in pharmaceutical sciences in the 3rd and 4th year of study. In addition, graduate and postgraduate students in chemistry, biology and medicine could also take advantage of the virtual learning environment ***Pharma²***. During the development phase, the course is available in German only. The extension to an English and a French version will be provided at a future point in time.

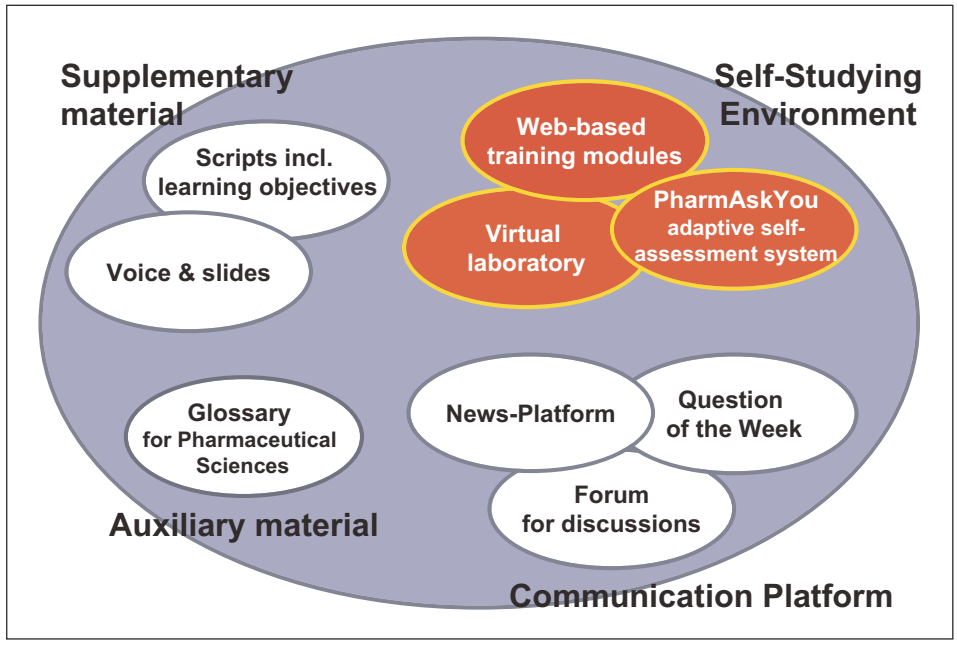

Fig. 1. The web-based learning environment ***Pharma²***

Pharma² can be accessed by all students independently of their technical equipment; from 56K modem technology up to ADSL users. *Tetrodo*, the architecture of the framework (see section 5), is currently developed. It will provide the presentation mode suited to the technology available at the student's site.

2.3. *Self-study Environment*

Based on our already existing infrastructure, we will establish a course of pharmaceutical chemistry/medicinal chemistry for students in life sciences at the Universities of Basel, Neuchâtel and the ETH Zürich. The course will consist of modules covering different therapeutic indications and will form part of the undergraduate studies in Pharmaceutical Sciences.

The self-study part contains three elements, namely web-based training modules, a virtual laboratory and an adaptive self-assessment system.

The **web-based training modules** allow students an individual preparation for regular lectures or secondary studies of topics of special interest. Currently, two preparation modules ('Enzymes', 'Heterocycles as Substructures of Pharmaceuticals') and two modules accompanying the regular Telepoly lectures ('Diabetes mellitus', 'Cardiovascular Diseases') are available (see Fig. 2).

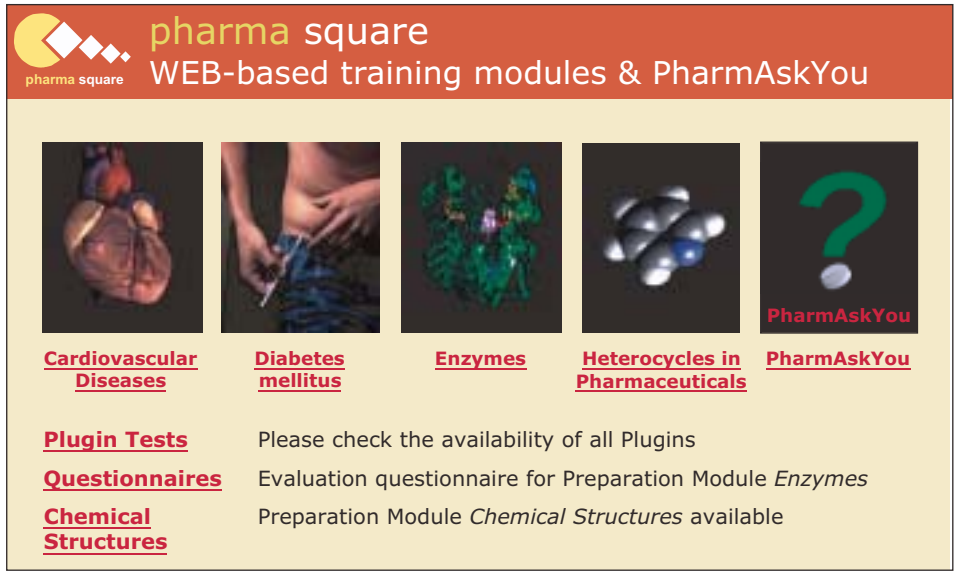

Fig. 2. Entry page to the self-study environment of ***Pharma²***

The contents of the modules are structured according to *learning pathways*. Depending on the interest, the prerequisites or prior knowledge, the student has the choice of different levels of complexity to interactively explore a certain topic of the module, *e.g.* Pharmacotherapy of Diabetes. The content is assembled to meet the individual needs and interests of the student according to his/her background. At the most complex level this includes a detailed discussion of the molecular level of structure–activity relationships of modified insulin and the consequences for pharmacodynamics and pharmacokinetics. This would be a typical content for pharmacists interested in molecular properties of bioactive compounds. Hence, the course has a matrix structure of cognitive information, experiments and case studies.

In the **Virtual Laboratory**, (see Fig. 3) which is integrated into the web-based training modules, the students have the opportunity to practice the complex interdisciplinary process of drug research. Here the students can experience how the molecular properties of drugs and drug candidates affect their pharmacokinetic and pharmacodynamic properties. The virtual laboratory offers interactive learning; *i.e.* the students can start with the chemical structure of a drug or a drug candidate and evaluate its pharmacological properties on a molecular level. In a next step, the structure of the drug can be modified and the consequences on pharmacodynamic and pharmacokinetic properties can be studied. Furthermore, synthetic concepts for interesting drug candidates can be developed interactively.

The self-assessment system ***PharmAskYou***, which will allow the students to monitor their learning progress, is currently being developed. It will be adaptive, *i.e.* it will be possible to create the subsequent test of the individual session according to the results of the previous one. This will offer the students an individual development of their skills and scientific knowledge.

An important aspect of the self-assessment system is the possibility to pose questions of different taxonomic levels [8][9]. On the beginner's level, students are asked to answer purely knowledge-based questions. Higher taxonomic levels deal with problem-oriented applications of pharmaceutical knowledge, analysis of case studies and finally content assessment.

2.4. *Supplementary and Auxiliary Material, Communication Platform*

Supplementary material as scripts and learning objectives from the Telepoly lectures are available on the Internet. In addition, courses from leading experts in pharmaceutical chemistry will also be provided *via* 'voice and slides'. A glossary for pharmaceutical sciences is currently in preparation and will support the students within the self-study environment. The communication platform offers a news page and a forum for discussions between students, tutors and professors. Finally, the students will have the opportunity to make contributions to the 'Question of the Week', which covers demanding aspects of topical interest in pharmaceutical chemistry.

3. Educational Concept

The educational concept is based on a blended learning approach. Whereas the major part of the theoretical knowledge is presented in Telepoly lectures (see Fig. 4), individual learning is offered within the virtual learning environment. We still consider face-to-face communication between students and professors as very important [10]. However, with the blended approach the increasingly important self-study process of our students can be accomplished. In addition, e-learning opens up the huge field of animations and interactive presentations of learning contents.

The Virtual Learning Environment is fully integrated in the curriculum as a supplementary teaching method (see Fig. 5). Students work in the virtual learning environment either before or after Telepoly lectures. With preparation modules the face-to-face lectures can be started on a common knowledge basis, the introductory part can be shortened and the saved time can be used for extended discussions of complex issues.

For the encouragement of the students to revise regularly the content of the Telepoly lectures, repetition modules and an adaptive test system are available (Fig. 5). Historically, tests were written on paper. To facilitate this process, a self-assessment tool called ***PharmAskYou*** [11] is currently in development, which will make possible the individualization of the student's learning process. Based on the individual success of a student, ***PharmAskYou*** will compose the next test of the session according to the result of the previous one. This approach, which is based on the learning objectives, will allow the teacher to closely follow the students' development in Pharmaceutical Chemistry and, at the same time, offers the students control over their individual learning progress. In addition, the students will also receive recommen-

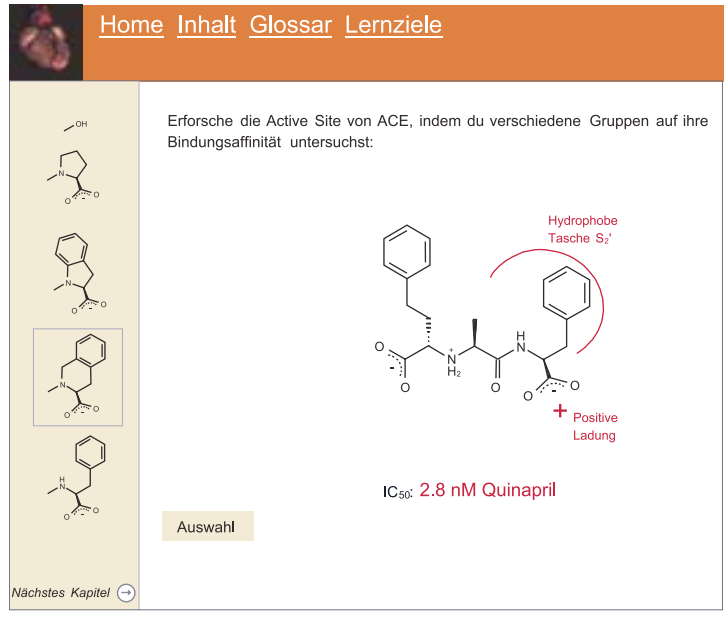

Fig. 3. Example of an exercise in the Virtual Laboratory

Fig. 4. Telepoly lecture hall at the University of Basel: The lecture is alternately presented in Basel and Zürich with synchronous transmission (on the left the audience in Zürich and on the central screen the slides are presented).

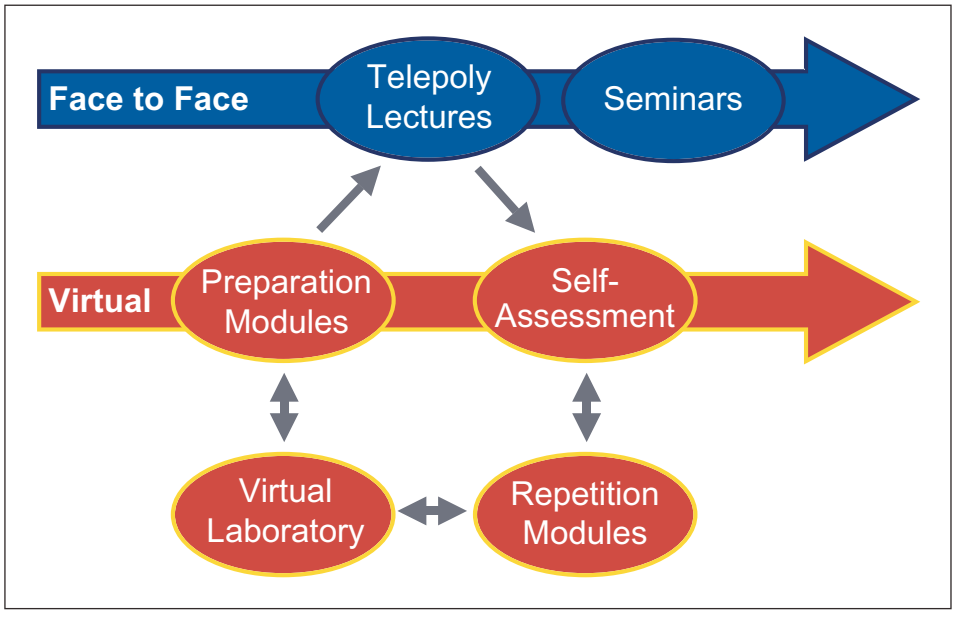

Fig. 5. Educational concept of the virtual learning environment

dations for consolidating studies. Beside the solution of the technical aspects (see section 5), a pool of questions categorized according to the taxonomy of Bloom [8][9], is currently being generated.

4. Evaluation

As improving the quality of teaching is one of our major goals, a continuous evaluation of the course implementation is indispensable. A formative evaluation offers the necessary feedback. In an interactive peer-review process, groups of 10 to 15 volunteer undergraduate and graduate students evaluates each module before its implementation into the self-study environment.

Supported by LearnTechNet of the University of Basel [3] and the eQuality-mandate of the Swiss Virtual Campus, different questionnaires have been developed to evaluate the modules in field tests.

5. Technical Realization

The heart of the information system is the ***Tetrodo*** framework, which consists of several java classes allowing a flexible, hardware- and content-independent development of an e-learning system.

The differentiation into four areas, a content, a presentation, a pedagogic and a didactic part, is a key element of the ***Tetrodo*** framework. A strict separation between those areas and a good representation of the data format is needed. The extensible Markup Language (XML) is the right way to fulfill that part [12]. It is a meta-language for document description derived from SGML (ISO 8879). Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the web and elsewhere. Within ***Tetrodo*** XML is used extensively for data description and storage.

This leads to the following layer structure of the ***Tetrodo*** framework (see Fig. 6). Pharmaceutical chemists prepare the content whereas the decision of the presentation mode should be left to a person with didactic and pedagogic knowledge. Finally, a person specialized in media design would ideally define the graphical format of the question. Similarly, feedback on the completed test may also be given in different ways and is controlled by a tutor specialized in pedagogic issues. The separation of the four areas has a major advantage: Content can be added, updated or exchanged by the content manager without didactic or information support.

In the ***Tetrodo*** architecture, information is stored in the XML database Xindice from the Apache group [13]. For specific content, XML derivates such as CML (Chemical Markup Language) [14], MathML [15] and SVG (Scalable Vector Graphics) [16] are used. Pedagogic and didactic information as well as information about completed tests are also stored in XML format. Scorm (Sharable Content Object Reference Model) [17] defines a web-based learning 'Content Aggregation Model' and 'Run-Time Environment' and is used wherever possible (Fig. 6).

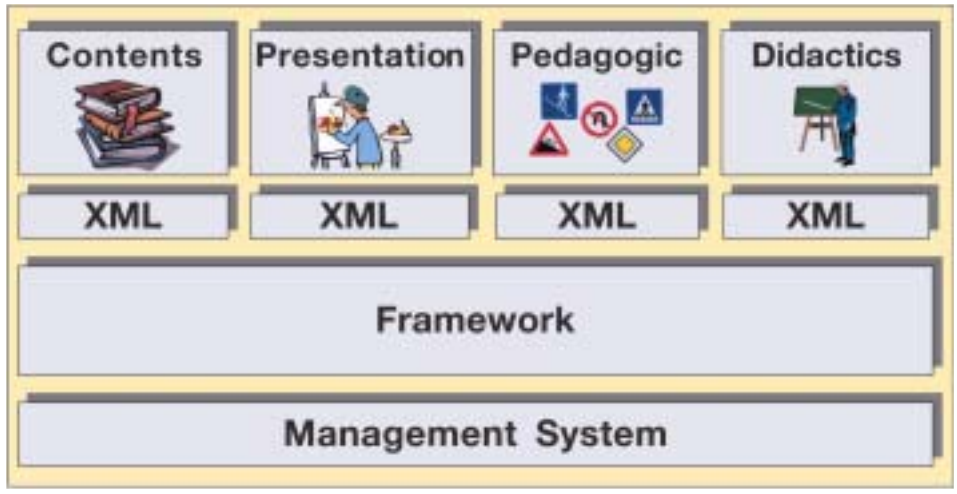

Fig. 6. Architecture of the ***Tetrodo*** framework

6. Project Status and Final Remarks

The four preparation and repetition modules on enzymes, heterocycles in pharmaceuticals, diabetes mellitus, and cardiovascular diseases have been successful implemented and partly evaluated. In March 2003 a first prototype of ***Pharm-AskYou*** will be available for students.

The individualization of the learning process is only possible within the framework of computer-based training and is the major advantage of the virtual learning environment compared to traditional teaching and learning. It is a substantial step towards the ambitious goal of an improved pharmaceutical education.

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