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How to Provide Feedback to Students' Learning – Assignment and Feedback Concept in the Blended Learning Environment *pharma²*

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Abstract: In traditional university teaching and learning settings feedback to students' performance is often neglected even though it is known to be an important factor to improve learning outcomes. Therefore we placed strong emphasis on this topic while developing and implementing the blended learning concept ***pharma²*** into the curriculum of pharmaceutical sciences. ***pharma²*** combines traditional face-to-face teaching with computer-based learning and testing tools. Once implemented, computer-based testing tools allow frequent feedback to large groups of students. However, commercially available systems show limited possibilities for demanding question and assessment types. Thus we developed ***PharmAskYou*** and ***ViLab***. ***PharmAskYou*** makes e-testing on higher cognitive levels possible and allows immediate and response contingent feedback. ***ViLab*** offers the opportunity to practice demanding lab methods online in the form of video sequences and interactive tools. While working through the method step by step the students receive response contingent feedback. Beside the possibilities of these computer-based testing and online feedback forms other assignments, *e.g.* reports and posters, followed by an individual feedback by the instructor are implemented into the blended learning concept. We consider the continuity of different assignments and constructive feedback important for students' motivation and hence learning progress. Even though developing and operating a didactically adequate feedback system is time-consuming it is worthwhile when students' performance can be improved as shown in our setting.

Keywords: Assignment · Blended learning · Feedback · e-Learning · *pharma²*

Introduction

Feedback in teaching–learning situations is the response to a student's performance in an assignment, *e.g.* essay writing, multiple-choice tests. It informs the learner about the quality of his or her work and contains, in the simplest form, the right result, or in a more sophisticated form, explanations why an answer is right or wrong as well as motivational elements. Undoubtedly [1], appropriate and performance-related feedback during the learning process positively influences the learning motivation, and therefore, the learning outcome. However, until recently traditional university teaching, *e.g.* in pharmaceutical chemistry, often lacked feedback to students during semesters. Apart from some tutorials and lab courses – often in groups of up to 30 students – most teaching was held in the form of lectures in even larger groups. After three or four semesters the students had to pass an oral exam based on the content of the whole course. This final exam and the grade they accomplished was the only feedback the students obtained regarding their performance.

Thus, the improvement of feedback to the students during the semester was one of the major goals when developing the blended learning concept ***pharma²*** (pharmasquare) [2] for the pharmaceutical chemistry course at the University of Basel and ETH Zürich. A combination of face-to-face teaching and e-learning components broadens the range of possible assignments even for large classes by implementing computer-based tasks, *e.g.* mandatory or voluntary tests. In addition, we not only enlarged computer-based feedback, but also cross-linked face-to-face teaching and e-learning components by a variety of assignments and feedback.

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pharma²

The blended learning concept ***pharma²*** is divided into two major parts, each containing three components [3]. The face-to-face part represents *traditional lectures*, *seminars* and *practical lab courses*. The e-learning part consists of ***PharmModules***, ***PharmAskYou*** and ***ViLabs***.

The implementation into pharmaceutical chemistry is based on the lecture 'Molecular mechanisms of drugs' given by Prof. Beat Ernst in Basel and formerly by Prof. Gerd Folkers in Zürich. During seminars, further and more complex topics are discussed. The aims of the laboratory course are the practical realization of a lead optimization cycle by molecular modelling of the interaction of a lead peptide with a target protein, and the design of peptide mimetics (part I), the

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Table. Assignments and feedback in the blended learning environment *pharma²,* realized in the course: Pharmaceutical Chemistry

Type of assignment	Online/ offline	Point in time	Voluntary/ mandatory	Content	Function	Time of Feedback	Type of Feedback
Entrance test	offline	first lecture	mandatory	basic chemical knowledge	check of previous/basic knowledge	two days later	knowledge of correct result
Entrance test	offline	start of practical course	mandatory	basic knowledge	check of previous/basic knowledge	one day later	knowledge of correct result
Self-assessment (Stob)	online	five Stobs per term	mandatory	content of modules and lectures	feedback over individual level of proficiency; realization of given learning objectives	end of test period	response contingent feedback
Self-assessment	online	as often as needed	voluntary	content of modules and lecture	feedback over individual level of proficiency; realization of given learning objectives	immediately	response contingent feedback
Self-evaluation	online	as often as needed	voluntary	content of module	check of understanding	immediately	knowledge of correct result
Self-evaluation	offline	start of individual lectures	mandatory	content of preparation-module	cross-linking online/offline; Feedback on individual level of proficiency	immediately	knowledge of correct result
Question of the week	online	every week	mandatory	content of module, lecture and seminar	examination of content	four days later	knowledge of correct result
ViLab	online	before start of practical course, part III	mandatory	lab methods	independent preparation	immediately	response contingent feedback
Report	offline	end of practical course, part III	mandatory	content of practical course, part III	understanding of content and evaluation of received results (realization of learning objectives)	one week later	Individual discussion
Poster	offline	end of practical course	mandatory	content of practical course	cross-linking of different practical course topics	immediately	poster session, best poster award
Oral exam	offline	end of the year	mandatory	content of modules, lecture and seminar	final feedback on individual level of proficiency	immediately	grade

synthesis of peptides and mimetics thereof on solid phase in the chemistry lab (part II), and finally the biological evaluation of the compounds in a bioassay (part III) (see also article by A. Vedani, O. Schwardt, S. Rabbani and B. Ernst [4] in this issue).

The so far thirty web-based training (wbt) modules of ***PharmModules*** are interactive and animated online courses designed for preparation or repetition of face-to-face lectures. ***PharmAskYou*** is ***pharma²***'s online test and training system. With didactically designed questions and question types such as drag-and-drop and line-connection, it allows testing of cognitively demanding issues [5] beyond simple multiple-choice questions. ***ViLab*** (video-based interactive laboratory) is an online learning system that allows preparation for challenging lab methods, *e.g.* SDS-PAGE or Western blot. It optimally prepares the students for the work in the lab, independent from expensive lab equipment and assistance-time.

All parts of ***pharma²*** are highly interconnected and dependent on each other. A typical example is the subject of influenza: the topic starts with the wbt-module 'flu' which is a preparation for the face-to-face lecture on neuraminidase inhibitors. To prepare for the lecture, the students review the basics of the disease mechanism and the virus on the macroscopic and cellular levels. During the lecture, molecular mechanisms of the drugs can then be discussed on a common basis. In the seminar, the molecular interactions of the drugs with the target are further deepened and discussed. Finally, there is a mandatory self-assessment in ***PharmAskYou*** covering the content of the wbt-module, lecture and seminar.

Although the blended learning concept has been realized to meet the demands of the course in pharmaceutical chemistry at the University of Basel and the ETH Zürich, it is applicable to other courses in various areas, and the different importance can be attributed to the different components of the learning environment.

Assignments and feedback in *pharma²*

To guarantee the continuous progress feedback to the students already during the semester, the following tasks and assessments are implemented into the course of pharmaceutical chemistry (see also the Table).

A thirty-minute written entrance test is held at the beginning of the course 'Molec-

ular Mechanisms of Drugs' as well as in the first part of the practical course 'Modern Drug Design'. In these tests, the important theoretical background knowledge is assessed. In addition, the results provide the instructor with an overview of the students' previous knowledge, and the students with the information concerning the knowledge required for a successful participation in the courses. The results of the tests are discussed during a seminar two days later.

The credit points of the seminar 'Molecular Mechanisms of Drugs' can only be acquired by solving at least four out of five online assessments called 'Stob' (Standortbestimmung) in ***PharmAskYou***. Stobs are computer-based learning assessments, which are based on the learning objectives of ***PharmModules***, the lectures and the seminars. Each Stob consists of six to ten questions varying from simple multiple choice up to drag-and-drop or line-connection questions (Fig. 1). The online feedback to each question not only gives the right answer, but also the reason why an answer is right or wrong: a so-called response contingent feedback (Fig. 2). If the instructor identifies the need for the results of the test to be discussed within the seminar, this can take place with only a two-day delay. Thus, the learning progress and the learning deficits are revealed to the students and to the instructors.

Besides these mandatory Stobs, there are also voluntary self-assessments offered in ***PharmAskYou*** for different topics. These tests also provide response contingent feedback. Moreover, each wbt-module includes some multiple-choice tests for voluntary self-evaluation.

To cross-link the face-to-face events with the e-learning components, a five-minute self-evaluation takes place at the beginning of each lecture requiring the students to prepare themselves with a wbt-module. For this purpose, a maximum of ten most likely multiple-choice questions are handed out to the students. A few minutes later the correct answers are presented. If necessary, the results are briefly discussed. With these self-evaluations the students are regularly informed whether their self-preparation was successful or needs to be improved.

The aim of the ***question of the week***, another element of ***pharma²***, is the active discussion of lecture content. After each face-to-face lecture, two students have to phrase an open text question about the current topic, which will then be available on the virtual learning environment. Three days later the group releases the correct answer. To offer an incentive to the students, the best questions will be integrated into the final exam.

The precondition for the admission to the practical course is the successful processing of ***ViLab*** (Fig. 3). The video-based, interactive learning system allows the students to independently prepare themselves for demanding lab methods without consuming expensive laboratory resources and personal supervision. The theoretical basic knowledge of the method can be acquired with the aid of a wbt-module. Subsequently, the laboratory method can be simulated step by step as often as necessary. Detailed video sequences, interactive tools and response contingent feedback guide the student through the method. The chemical compounds needed for the experiment are described in an extensive chemical glossary.

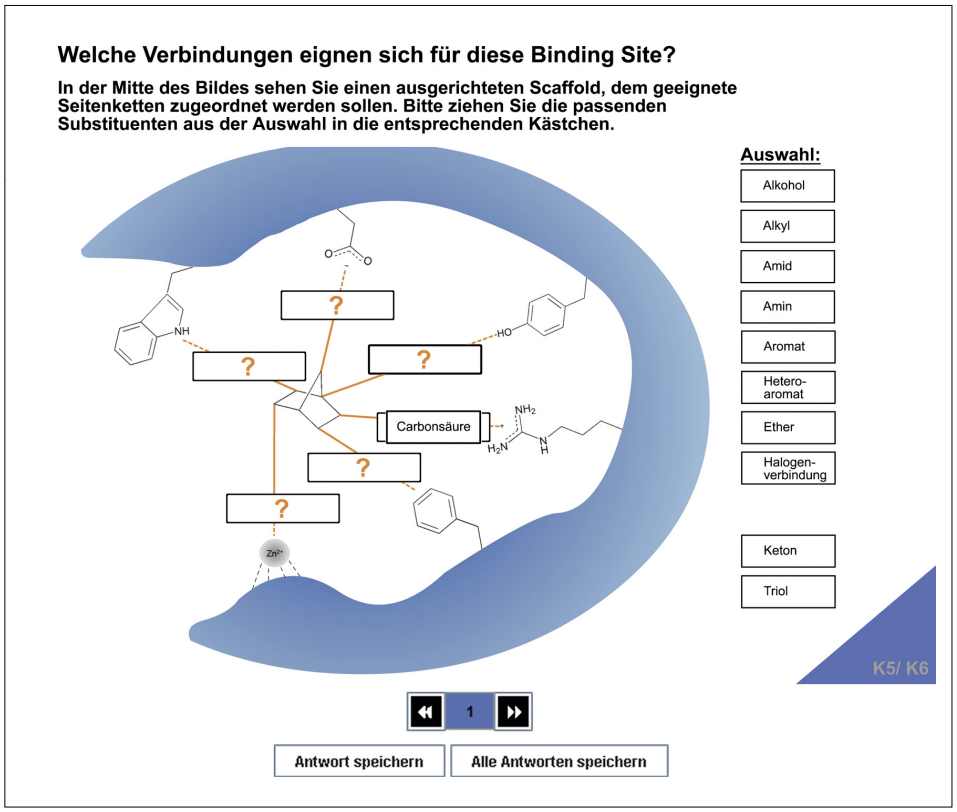

Fig. 1. Screenshot of ***PharmAskYou***. It shows a question about drug design. The students have to identify feasible substituents, and drop them into the suitable area of the binding site. K5/K6 indicates that for answering this question synthesis and evaluation of gained knowledge is needed.

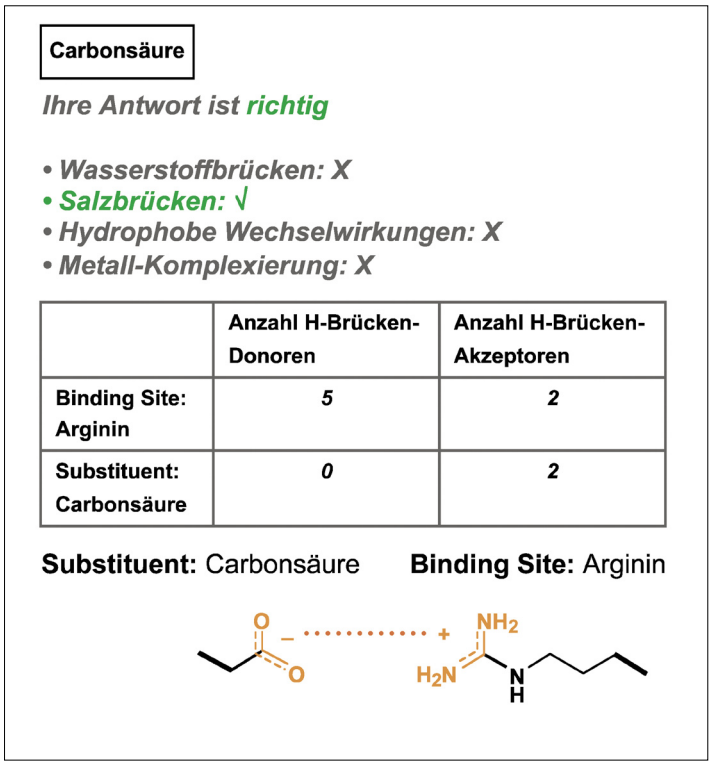

Fig. 2. Screenshot of ***PharmAskYou***. Response contingent feedback to Fig. 1.

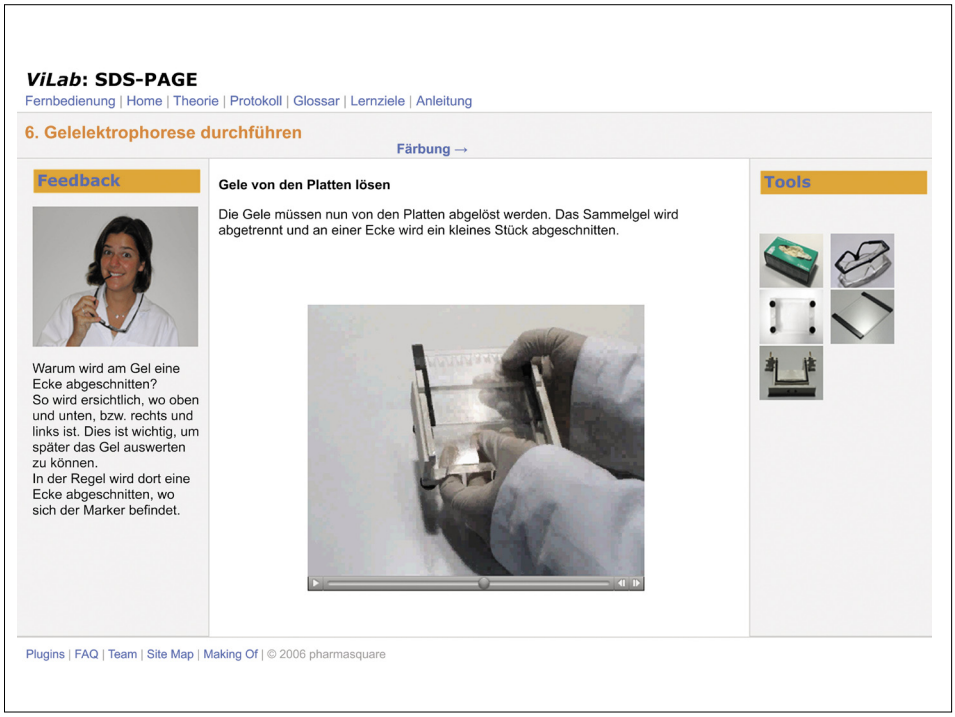

Fig. 3. Screenshot of ***ViLab***. ***ViLab*** uses images and text (left: assistant giving response contingent feedback), film (centre: film clip of the experiment) and interactivity (right: tools which are to be used at the appropriate time).

Finally, personalisation allows the laboratory journal of each attempt to be stored or printed. Only the successful and therefore correct experiment qualifies the students to attend the real lab course.

To assure that the students understand the content of the practical lab course and are able to correctly interpret their results, they are asked to write a report about part III of the lab course. The reports are discussed in an individual meeting in the following week.

To finalize the practical course, the students present their data plus an overall discussion in a poster session. Thus the students have the opportunity to demonstrate their ability to cross-link the three topics of the lab course. A prize is allocated for the best posters.

Following the semester, the students have a few weeks to prepare themselves for the final oral exam. During this period, all online components are still available. The performance at the exam is graded in the traditional way with grades ranging from one to six.

Implementation and Students' Evaluation

pharma² has been part of the curriculum of pharmaceutical chemistry for two years. Within this period, the online components were gradually extended taking the positive students' evaluations into account. The evaluations emphasized that students appreciate the frequent testing and suggest even more frequent intervals . Commercially available online test systems usually allow only simple single- and multiple-choice questions which do not meet the requirements of demanding topics in pharmaceutical chemistry. With the development of ***PharmAskYou***, frequent testing became possible even on higher cognitive levels. Since the time-consuming correction of the tests is delegated to the computer, large groups of students can be examined as often as desired.

With the implementation of ***Vilab*** targeting the preparation for practical courses, students now have the opportunity to practice lab-methods on the computer before actually working in the laboratory. This has clearly led to an improvement in their achievements: they perform the lab-work more efficiently and understand the theoretical background much better. Compared to the previous setup, expensive reagents and valuable time of teaching assistants are saved.

Finally, by keeping track of the students' performance in the final oral exams over the past two years, a clear improvement was undoubtedly documented.

Conclusions

With an intensive and time-consuming effort, a didactically adequate development and implementation of computer-based and traditional assignments and feedback was realized. However, the numerous positive effects fully compensate the large investment. The students are guided to apply and test their knowledge during the semesters and thus are better prepared for the demanding final exams. The improvement in online testing on cognitive levels above simple understanding and reproduction combined with a frequent feedback turned out to be particularly important. Although the development of online assignments, *e.g.* tests or ***ViLab***s is extremely time-consuming, once established, they offer immense advantages. They are not only available for a large group of students, but are also automatically corrected with regular response contingent feedback.

Moreover, our blended learning concept is not limited to pharmaceutical chemistry. The e-learning parts of ***pharma²***, *i.e.* ***PharmModules***, ***PharmaAskYou*** and ***ViLab***, are based on ***Tetrodo***, a framework that has been developed in collaboration with the Department of Informatics at the University of Basel (Prof. Helmar Burkhart, Sven Rizzotti). ***Tetrodo*** applies open standards like XML to separate content, presentation, pedagogy and didactics. This separation allows the simple integration of content from other scientific disciplines for the establishment of learning environments such as, for example, ***biosquare*** or ***artsquare***.

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