

# Evaluation of a Case-Based Training System (d3web.Train) in Rheumatology

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## Abstract

**Objective:** We introduce a case-based training program using the novel system d3web.Train. It allows fast development of case studies for a computer course using available clinical patient records. We evaluated the training program during a rheumatology course for medical students.

**Methods:** Students received a short introduction into the system (d3web.Train) and a personal anonymous code. The code enabled us to record how often and intensive a student used the system. In addition, we offered the students two questionnaires: one to evaluate each case and another one to evaluate the training system overall.

**Results:** 92 students attended the training program. 39 students finished at least one case. Overall 187 cases were solved, in average students solved 4.8 cases. For working through one case, students needed 12 minutes in average. 24 different students filled in the questionnaire concerning the program, 62 questionnaires about individual cases were collected. The students evaluated the cases as very instructive ( $1.5 \pm 0.6$  on a scale from 1 to 5), the training system as very good ( $1.7 \pm 0.8$  on a school grade scale from 1 to 6) and want to work further with it ( $1.3 \pm 0.5$  on a scale from 1 to 5).

**Conclusion:** The training system d3web.Train offers a new and good tool for medical education in rheumatology. The main advantage of the system is the relatively low effort needed to create a case based program starting from available medical records.

## 1 Introduction

Lectures are one of the most important tools in medical education. In addition, students receive bedside teaching, seminars and they participate in rounds. Furthermore the study of medical text books is used to achieve medical knowledge. However, careful evaluation of a patient, assessment of clinical investigations and developing the differential diagnosis of a disease are hard to learn.

The "new media", including digital imaging and the World Wide Web, offer new opportunities for medical education and training in rheumatology [1]. Very promising examples are web-based portals, which offer information and knowledge not only for patients, but also physicians [2]. Other examples are case-based training systems which have already been used in the medical training of students. These interactive systems are valuable tools in medical education and they were highly appreciated by students [3, 4, 5, 6].

In 2002 the guidelines for medical education in Germany have been changed. Since then, medical education is less focused on multiple-choice-questions, but more emphasis is given to the students' capability to develop the complicated differential diagnosis of a patient [7]. In order to achieve this goal, problem oriented and case-based learning is highly appreciated. Since patients are not always available, creation of case-based training systems for medical education in rheumatology has been highly recommended [8].

Therefore we decided to develop a new case-based training program, which we present in addition to the basic rheumatology lectures. For our program, we created 12 interactive rheumatology cases. Students in their third and fourth year of medical education have access to these cases via the internet. We developed the cases from real patients as they were presented in our outpatient and inpatient unit. First we report the patient's medical history and review of systems. In addition we present the physical examination, the laboratory parameters, x-rays and results of other important technical tests. Important results are enriched by several digital images and corresponding multiple choice questions. By reading through the cases and solving the questions, the students are not only introduced to the main diseases in rheumatology, but also train their ability to work up the differential diagnosis.

In this paper, we evaluate the acceptance and usefulness of our case-based training program by medical students. We compare our evaluation with other case systems as „Rheumatrainer“ [3, 9], CAMPUS [10] and CASUS [4].

## 2 Methods

### The training system d3web.Train

d3web.Train[11] is an intelligent case-based training system provided in the web with the goal to provide the student the opportunity to play the role of a remote doctor working on an electronic patient record (EPR). To achieve this goal d3web.Train enables the student to do five kinds of actions repeatedly: 1. to order examinations, 2. to interpret results (e.g. pictures like a radiograph), 3. to choose a diagnosis 4. to make treatment decisions and 5. to plan follow-up treatment. In a prestudy [12] to this evaluation, the students most acknowledged the action types 2 and 3. Therefore only these two actions types were activated. This simplifies the user interface and allows the students to work through a case quite fast. We intend to evaluate the other action types in further studies, e.g. with more advanced students.

Fig. 1 gives an impression about the user interface of the training system and the tasks the student has to do. The user gets data about the patient successively, (upper screen, right side in fig. 1) split in the flags “Medical history”, “Physical examination”, “Laboratory parameters”, “Technical tests”, “Special technical tests” and has to enter his current diagnoses (upper screen, left side). Some patient data comprehend multimedia information, which the student has to interpret by answering a multiple choice question (e.g. the images of the physical examination in the lower screen).

### The authoring component of d3web.Train

The *Phoenix* module of d3web.Train [16] allows a faculty teacher to create a new case from routine patient records and the dismissal record by annotating it with little additional information in a standard text system (e.g. Microsoft® Word). The dismissal record should contain the final diagnoses and the results of all tests. The teacher’s annotations add the list of diagnoses in the domain, from which the student has to choose (part of them are shown in the upper screen on the left side in fig. 1). Furthermore the teacher adds a list of available tests together with their arrangement in flags (see above), the intermediate diagnostic results and the multimedia information. If the latter are pictures, they are simply copied into the medical record together with the correlating multiple choice questions (left part of the lower screen in fig. 1). The edited record is uploaded via a web interface to Phoenix, which generates a case presentation as shown in fig. 1 automatically and adds it to the pool of case presentations of d3web.Train.

### The training scenario

To support the education in rheumatology, which is part of the classes in internal medicine (students in their third and fourth year of medical school), 12 training cases were created. The cases covered the main topics in rheumatology and supplemented the corresponding lectures (Lecture 1: Arthritis, Lecture 2: Connective Tissue Diseases, Lecture 3: Spondylitis and vasculitis disease).

#### Overview of the Cases:

Case 1+2: Rheumatoid Arthritis

Case 3+4: Psoriatic Arthritis

Case 5+6: Systemic Lupus erythematosus

Case 7+8: Systemic Sclerosis

Case 9+10: Bechterew's disease  
 Case 11+12: Wegener's Granulomatosis

The screenshot shows the d3web.Train interface in Microsoft Internet Explorer. The top navigation bar includes 'd3-Train', 'Polyclinic Rheumatology', 'You are working on: Case 1 (Rheumatology)', a user profile for 'James S. Tudent', and a timer 'Time needed: 0h 08m 33s'. The main area is divided into two panels:

- Your actions (left):** Contains buttons for 'next', 'Start Images etc.', 'Choose Diagnoses', and 'End case'. Below these is a list of diagnostic options with checkboxes: Rheumatoid Arthritis, Vasculitis, Polyarteritis Nodosa, Churg-Strass Syndrome, Wegener's Granulomatosis, Hypersensitivity Vasculitis, Giant Cell Arteritis, Takayasu Arteritis, Fibromyalgia, Acute Gout, Reiter's Syndrome, Systemic Lupus Erythematosus, and Systemic Sclerosis (Scleroderma). A search bar and a 'Text search' button are also present.
- Patient record (right):** Shows the 'Physical Examination' section with a text description of a 40-year-old female patient. Below the text are two diagrams of hands labeled 'Tenderness joints' and 'Swollen joints', each with a score of 17 and 16 respectively. A feedback message states: 'You can see the following subcutaneous nodules on the pictures: You have to answer a question first.'

This screenshot shows the 'Edgar' character, a cartoon doctor, providing feedback. The text reads: 'Your Diagnosis is very good (100%). Following diagnoses are correct: [Similarity: 100%, Weight: 1.0, Points: 1.0] Rheumatoid Arthritis actually is established. The rating is based on the following graduation: 0-15% = insufficient, 15-30% = inadequate, 30-50% = sufficient, 50-70% = satisfying, 70-85% = good, 85-100% = very good.'

This screenshot shows the 'Your answer for' section of the d3web.Train interface. It includes a 'Questions to answer' section with a question: 'Which subcutaneous nodules can you see?'. Below the question is a list of options with checkboxes: Lipomas, Parasitic infection (filaria), Rheumatoid nodules, and Skin granuloma by tuberculosis. A 'submit' button is at the bottom. To the right, the 'Available images etc.' section displays a grid of images, with a larger image of a hand showing subcutaneous nodules selected for viewing.

Fig. 1: Screenshot of d3web.Train with patient record (up right), actions (up left) and multimedia-interpretation (down).

The students were asked to fill in two online questionnaires during their work with the case-system: one question on each case and one question on the training system overall. The second questionnaire was split into two parts: one question was asked if the student had solved the first case and another question was asked after solving the fifth case. Since only four students filled the questionnaire twice, we used the answer regarding the first questionnaire of each student and do not report on the second one.

At the end of the rheumatologic lectures, the students were asked to write a voluntary 15-minute exam consisting of 2 cases and 6 “case-oriented” multiple choice questions. For example, we showed some key symptoms of a patient and asked for the most reasonable diagnosis. Additionally, in an optional questionnaire, we questioned on the number of our internet cases that the students had processed (with the alternatives: 0, 1-4, 5-8, and 9-12). This optional question was necessary, because we could not correlate the statistics of the case-system with the individual results in the exams, since students received an anonymous internet account for the training system.

### 3 Results

About 92 students attended the course and received the opportunity to get direct access to the system. Until the end of the course 39 students worked through at least one case and solved 187 cases in total, i.e. in average each of these students processed 4.8 cases. The distribution is shown in fig. 2 (e.g. 3 students solved all 12 cases). For working through one case, the students needed 12 minutes in average with a standard deviation of 8 minutes. These data were extracted from a log-protocol of the session. 24 different students filled in the questionnaire about the training system (i.e. ca. 62% of the 39 students) and 62 questionnaires about individual cases (i.e. ca. 33% of the processed cases). 36 students of the course participated in the voluntary exam.

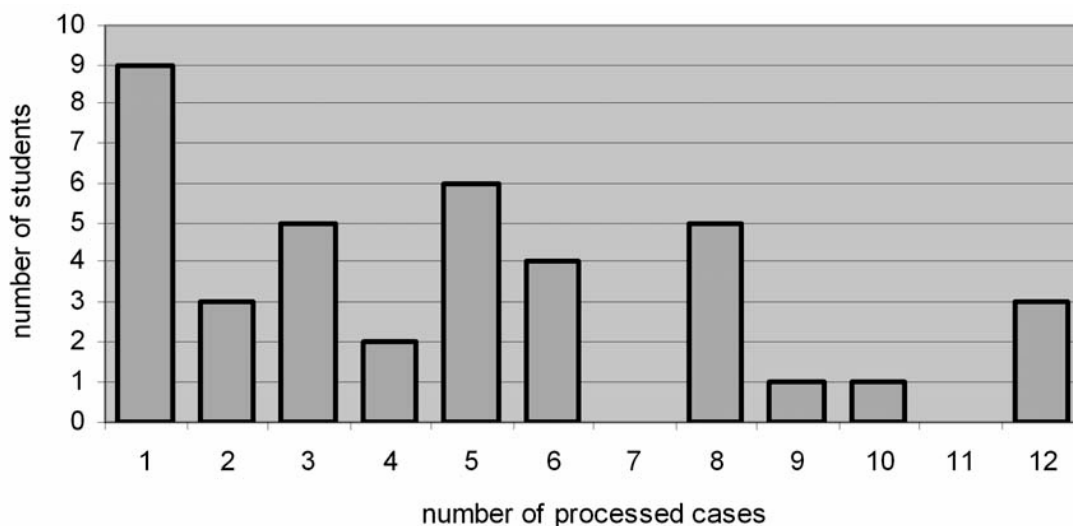


Fig. 2: The distribution of the number of cases processed per student (n = 39)

In our evaluation we measured three aspects: the subjective opinion of the students about the training program (fig. 3), their subjective opinion about the individual cases and the objective correlation between using the training system and their grade in the final examination (fig. 4).

All ratings in fig. 3 were between very good (1) and good (2) on a scale from 1-5 (for two questions even 1-6). The best grade was received by the question on students intention to work further with the system ( $1.3 \pm 0.5$ ). The system is assessed as a good complement to other learning forms ( $1.4 \pm 0.6$ ). The training system as a whole is valued with  $1.7 \pm 0.8$  and the program, to supplement the course with the training system as  $1.4 \pm 0.7$  on a grade from 1-6 (1 very good, 6 very bad). The optical presentation of the program was perceived as very good ( $1.5 \pm 0.7$ ). The grades for the orientation to get used to the program (1.9) and the usability (2.4) were slightly worse than the other grades, but still “good”. The same grades were obtained by the question, whether the

students learned from the program ( $2.0 \pm 1.0$ ). The instructiveness of individual cases (62 questionnaires) was rated quite well (1.5). The difficulty of the cases was rated as adequate by 73%, too difficult by 14%, and too easy by 13%. The judgments for the quality of the system feedback during processing the case was rated as fair by 87%, too good by 0%, too bad by 11% and totally inadequate by 2%. This feedback is generated comparing the system's diagnosis with the diagnosis of the student and therefore more difficult to calibrate as the extensive case discussion at the end of the case (not evaluated in the questionnaire).

The third part of our evaluation correlates the number of processed cases and the results of the final examination in the rheumatology part. Details are shown in fig. 4. There is no significant correlation between the number of solved cases and the results in the exam. This may be due to the fact that the first examination case, which was similar to one of the training cases, was very easy to solve.

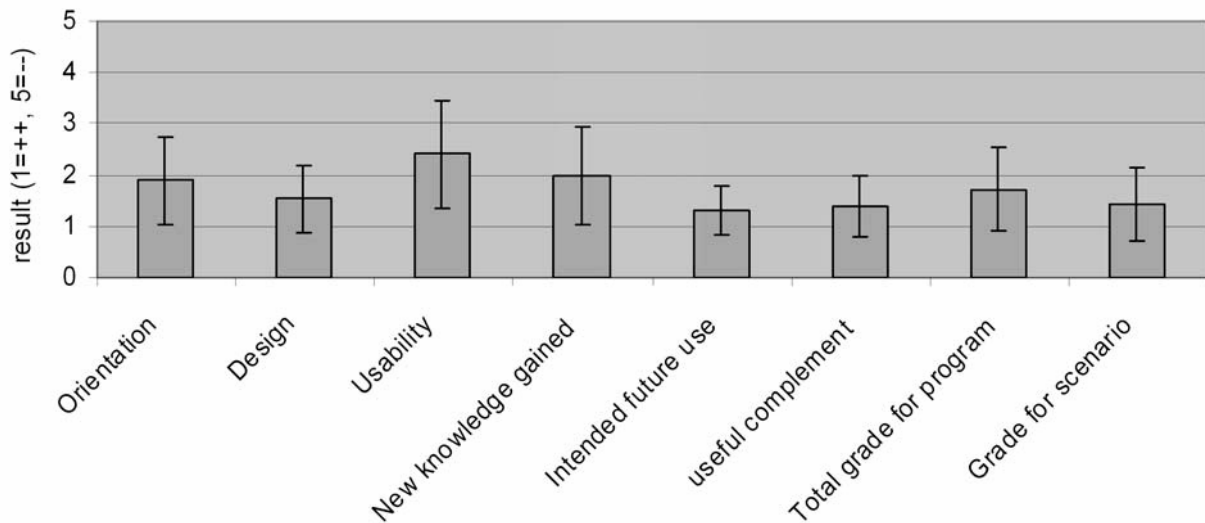


Fig. 3: Subjective opinion of the students (n = 24) about the training system (mean & standard deviation)

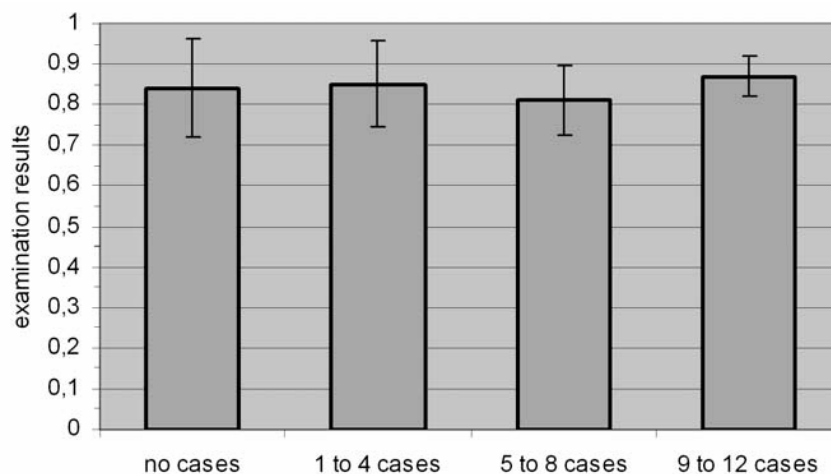


Fig. 4: Average score in final examination depending on number of processed cases per student (n = 36)

## 4 Discussion

Our evaluation shows that the program was very well accepted (fig. 3). We received the best grades for design (1.5), the system in general (1.7) as well as the intended future use (1.3) and the application as a useful complement to other learning forms (better than 1.7). These data indicate high satisfaction of the students with the training system. This result is in accordance with the evaluation of the case-based training system “Rheumatrainer” [9, 13 p.247-249]. The assessment of our program is slightly better in all investigated subjects as with “Rheumatrainer”. This might be due to a better acceptance of this learning method and simplification of the user interface of the program.

The grades for orientation, usability and gain of knowledge for our training system are good (between 2.0 and 2.4). The cases introduced in our training system were rated as very instructive (1.5). The judgment for the feedback of the system, while solving the case, was very positive (87% of the students rated the feedback as fair).

Our results are in line with many other studies about medical case-based training programs, e.g. in paediatrics with CAMPUS [10], in surgery [14] or in a variety of medical subjects with CASUS [4]. However, until now case-based training systems need an enormous amount of time to create the single cases. Therefore, the relation of benefits versus costs to create a case-based training program is very important.

We used the training system “d3web.Train”, which is a novel tool to develop a case-based system in a time saving manner [12, 16]. The system allows usage of an authentic patient dismissal record, written in a standard text system. The record is edited by erasing all personal patient data and by the addition of tutoring information (short case introduction, pedagogical case discussion, intermediate diagnoses based on partial information about the case, addition of digital images of clinical pictures, questions regarding these images, list of diagnoses, from which the student has to choose the right one). The total amount of time for case editing was about 12 hours per case: 10 hours for editing the case records as mentioned above, mainly due to the high number of pictures with corresponding questions, (2 - 21 pictures per case with an average of 10) which had to be added manually to the patient record; 2 hours for technical preparation, formatting the case and use of the program tool which generates the final training case. With fewer pictures per case and without tool problems for the technical preparation, the necessary time to create a case in the case-system might be much shorter. The system is flexible and can be individually adapted with little effort. The lecturer is able to customize the case-system according to his or her special favours and to show the same cases in the lectures, as in the case-system. Students missing lectures are able to keep up by solving the cases online whenever they want. The ability to create a whole case-system in a few weeks is the main advantage of d3web.Train [6].

Medical students, whose main problem is to learn a large amount to acquire knowledge for attending examinations, have to balance their available time budget. Working through case studies may take much time, depending on the amount of background knowledge integrated. Since the students learn the background knowledge as well in lectures and in textbooks, it is difficult to assess how much background knowledge in case studies is adequate. Therefore, we decided to separate the case from the background knowledge. The background knowledge is available as an option, but it is not integrated into the case. Therefore the student, who simply wants to check his or her diagnostic knowledge with case studies, can process the case quite fast. This procedure seems to be well accepted by the students, who needed only 12 minutes in average to solve a case. The low amount of time to process a case resulted in a relatively high percentage of processed cases (in average 40% of the available cases; see fig. 2). This is in contrast to other known case-based training systems mentioned above, where the average time to process a case is much longer. Evaluation of the average time to process a case in the training system CASUS [4] showed 43 minutes to be necessary for finishing a single case.

Besides the motivation of students, we also tried to measure the learning effects of case based training systems. However, the results showed no significant correlation between the number of cases processed and the grades in the rheumatology exam (fig. 4). Unfortunately, there were many factors and problems influencing the results of the exam. The two main problems were, that the exam was a voluntary test (39 from 92 students took part) and that the test was very short with a time of 15 minutes to solve 2 cases and answer 6 multiple choice questions. Additionally, the cases and questions were very easy, allowing even poorly prepared students to achieve good grades. These problems might have influenced the credibility of grades that students achieved in this exam.

To summarize, our results show that the novel d3web.Train system enables the academic teacher to generate a fast and flexible case-based training system in rheumatology. The case-system is welcome as addition to conventional teaching methods and is very well accepted by medical students. The d3web.Train system might be useful for the creation of more case-systems in rheumatology, not only for the education of medical students, but also for teaching of physicians in residency.

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## References

1. Sanford MK, Hazelwood SE, Bridges AJ, Cutts JH 3rd, Mitchell JA, Reid JC, Sharp G. Effectiveness of computer-assisted interactive videodisc instruction in teaching rheumatology to physical and occupational therapy students. *Journal of Allied Health* 1996;25(2):141-148.
2. Specker C, Richter J, Take A, Sangha O, Schneider M. RheumaNet-a novel Internet-based rheumatology information network in Germany. *Br J Rheumatol.* 1998;37(9):1015-9.
3. Schewe S, Quack T, Reinhardt B, Puppe F. Evaluation of a knowledge-based Tutorial program in rheumatology - a part of a mandatory course in internal medicine. *Proc. of 3rd. Int. Conf. on Intelligent Tutoring Systems (ITS-96)* 1996, Springer, 531-539.
4. Simonsohn A, Fischer M. Evaluation of a case-based computerized learning program (CASUS) for medical students during their clinical. *Dtsch Med Wochenschr* 2004;129, 552-556.
5. Langer I, Schewe S, Haeddecke C, Puppe F, Rheinhardt T. Learning at the computer: evaluation of an intelligent tutoring system. *Eur J Med Res.* 1998;21,3(1-2):119-26.
6. Reimer S, Kneitz C, Tony HP, Schewe S, Hörnlein A, Puppe F. d3web.Train: Erste Evaluationsergebnisse zum Einsatz in der Medizinerbildung an der Medizinischen Poliklinik der Universität Würzburg. In: Pöpl, S, Bernauer, J, Fischer, M, Handels, H, Klar, R, Leven, J, Puppe, F, Spitzer, K, editors. *Rechnergestützte Lehr- und Lernsysteme in der Medizin: Proceedings zum 8. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin*; 2004 Mar 25-26; Lübeck, Germany. Aachen: Shaker Verlag; 2004. p. 155-164.
7. Approbationsordnung für Ärzte. *Bundesgesetzblatt* 2002. Teil I Nr. 44 (Jun 03, 2004).
8. Keysser G, Zacher J, Zeidler H. Rheumatology: Integration into student training - the RISA Study. Results of a survey exploring the scale of education and training in rheumatology at German universities. *Z Rheumatol.* 2004;63(2):160-6.
9. Schewe S, Reinhardt B, Betz C. Experiences with a knowledge-based tutoring system for student education in rheumatology. In: *XPS-99: Wissensbasierte Systeme – Bilanz und Perspektiven*; 1999 Mar 3-5; Würzburg, Germany. LNAI. 1999. p. 193-200.
10. Ruderich F, Riedel J, Singer R, Heid J, Bauch M, Leven FJ, Köpf S, Seidel C, Tönshoff B, Starkloff P, Reimann P. CAMPUS in der Praxis - Evaluation im Rahmen eines pädiatrischen Praktikums. In: Bernauer J, Fischer MR, Leven FJ, Puppe F, Weber M, editors. *Rechnergestützte Lehr- und Lernsysteme in der Medizin: Proceedings zum 6. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin*; 2002 Apr 11-12; Ulm, Germany. Aachen: Shaker Verlag; 2002. p. 87-96.
11. d3webTrain.de [homepage on the Internet]. Würzburg: d3web.Train group at Chair for Artificial Intelligence and Applied Computer Science; c2002-04 [cited 2005 July 30]. Available from: <http://www.d3webtrain.de>.
12. Hörnlein A, Reimer S, Kneitz C, Betz C, Puppe F. Semantische Annotierung von Arztbriefen zur Generierung diagnostischer Trainingsfälle. In: Engels G, Seehusen S, editors. *DeLFI 2004: Die 2. e-Learning Fachtagung Informatik*; 2004 Sep 6-8; Paderborn, Germany. Berlin: Springer; 2004. p. 247-258.
13. Reinhardt B. Didaktische Strategien in generierten Trainingssystemen zum diagnostischen Problemlösen [dissertation]. Würzburg, Germany: Julius-Maximilians-Universität; 1999. Berlin: infix. DISKI 234;1999.

14. Zumbach J, Mehrabi A, Schwarzer H, Rentz C, Reimann P, Herfarth Ch, Kallinowski F. Wie beurteilen Studierende CBT-Module? Evaluation von Trainingsprogrammen in der Chirurgie. In: Koop A, Novak D, editors. Computerunterstützte Ausbildung in der Medizin: Proceedings zum 5. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin; 2000 Mai 11-12; Cologne, Germany. Aachen: Shaker Verlag; 2000. p. 113-125.
15. CASEPORT.de [homepage on the Internet]. Munich: Portal for Case Based Learning in Medicine; c2001-04 [cited 2005 July 30]. Available from: <http://www.caseport.de>.
16. Betz, C., Hörnlein, A., Puppe, F.: Experiences with Generating Diagnostic Training Cases from Dismissal Reports, submitted to this workshop, 2005.