Evaluation of a novel case-based Training Program (d3web.Train) in Hematology

Doris Kraemer[1], Stanislaus Reimer[1], Alexander Hörnlein[2], Christian Betz[2], Frank Puppe[2], Christian Kneitz[1]

[1] Medizinische Poliklinik der Universitätsklinik Würzburg, Klinikstr. 6-8, 97070 Würzburg
[2] Lehrstuhl für Informatik VI der Universität Würzburg, Am Hubland, 97074 Würzburg

Corresponding author

PD Dr. med. D. Kraemer

Medizinische Poliklinik der Universität Würzburg

Klinikstr. 8

97070 Würzburg

Germany

Phone : **(49) 931 201-36163**

Fax : **(49) 931 201-36286**

e-mail : **Kraemer_d@medizin.uni-wuerzburg.de**

Abstract

The new media such as the internet and digital imaging offer new opportunities in medical education. In addition to conventional lectures we developed a case-based simulation training program of 17 hematology cases using the novel training system d3web.Train. We evaluated the assessment of this internet course by medical students, as well as their results in the hematology exam.

From a group of 150 students, 47 worked through at least one case and solved 435 cases in total; in average these students solved 9.5 cases. 18 different students filled in the questionnaire about the training system and 68 questionnaires about individual cases. The main results were: the students found the cases very helpful (1.5 ± 0.6 on a scale from 1 = very helpful to 5 = not at all), the training system very good (1.4 ± 0.5 on a scale from 1 to 6) and want to work with it further (1.2 ± 0.4 on a scale form 1 to 5). During the final examination, those 16 students, who answered that they had solved more than 5 from the 17 cases, scored significantly better (two-sided t-Test, $p < 0.01$) in the hematological part of the exam than those 34 students solving 0 to 5 cases.

To our knowledge this is the first student evaluation of a case based training program in general hematology. The d3web.Train system offers a new and great tool for creating a training program in a reasonable amount of time, since it is able to process available patient records.

Key words

Educational Measurement – Patient simulation – Problem-based learning - Hematology

Introduction

Lectures are one of the most important tools in medical education. Additionally students receive bed side teaching, seminars and they participate in rounds. Another important part is the study of medical books and literature in the library or at home. Medical students should not only read the books, but also should understand the mechanisms how to develop the differential diagnosis of the patient.

In addition to books and lectures the new media such as digital imaging and the internet, offer new opportunities for medical learning and training in hematology. So far, these tools have been used for hematology atlases, as for example an interactive hematology atlas to teach examinations of blood films [13] or the “atlas of genetics and cytogenetics in oncology” [5]. Furthermore the new media have been used to create data bases as the hematology slide bank of the American society of hematology [1] or a database of immunophenotyping by flow cytometry to support diagnosis of hematological neoplasms [8].

Furthermore the internet has already been used successfully in virtual hematology education, as in examinations of peripheral blood smears [9], the education of pathologists [10], in a case oriented format to teach the differential diagnosis of anemia [6][2] or in multi parameter case studies to educate physicians and laboratory technicians in the use of different diagnostic tools to create a diagnosis in hematology [3]. In summary, the internet and the use of digital imaging might revolve the way we learn cytology and hematology. Not classes with smears and thin sections or atlases and text books might be the future, but digital courses in the internet.

In contrast to a paper from Brasilia in the year 2000, which showed, that only 53% of the medical students had used the internet before [7], all of our students had used the internet prior to this study. 64% have private access to the internet. Moreover free access for all medical students is provided by the university in different parts of the university hospital, in a special skills laboratory and in most theoretical medical institutes.

Since computers are available and our students are familiar with the internet technologies, we decided to use this medium for medical training. This decision was supported by a change of the medical education curriculum in Germany demanding a better training on clinical cases. As

already shown, for the differential diagnosis of anemia, case-based computer programs allow a good educational means and save teaching hours in the classroom [6].

We planned to integrate e-learning in our regular classes and lectures in internal medicine. To follow this goal, we developed 17 hematology simulation training cases in the intranet for our students in their third and fourth year of medical education. According to the ideas of problem-based learning we showed real cases, as they came to our emergency department. In this way the students are introduced to general cases in hematology and they are asked to think about the differential diagnosis. In addition we asked questions on the digital images of blood- and bone marrow smears to force the students to carefully look at the pictures. As shown in this paper, we evaluated this kind of teaching to see if e-learning is accepted and useful in medical education of our students. To our knowledge, such an evaluation of e-learning on real and general hematology cases has not been published so far.

Methods

The tool d3web.Train for building training systems

d3web.Train [16] is a novel intelligent case-based authoring and training system in the web with the goal to give the student the possibility to play the role of a remote doctor with an electronic patient record (EPR) [4]. To achieve this goal, the system enables the student to do repeatedly five kinds of actions:

1. to order examinations,
2. to interpret the results of the examinations (for example pictures like a bone marrow smear),
3. to choose intermediate and final diagnoses,
4. to make treatment decisions and
5. to plan the follow-up treatment.

In this study, only the action types 2 and 3 were activated. This simplifies the user interface, allows the students to work through a case quite fast and requires less work for the authors. Fig. 1 gives an impression about the user interface of the training system and the student’s tasks.

The user gets data about the patient (fig. 1, upper screen, right side) split into the tabs “Medical history”, “Physical Examination”, “Laboratory parameters” and “Technical tests” stepwise by pressing the “next” button (fig. 1, upper screen, top left). After getting new data, the student has to enter his or her current diagnoses (fig. 1, upper screen, left side). Some patient data comprehend multimedia information, which the student has to interpret by answering a question (for example the bone marrow smear in fig. 1, lower screen).

The authoring component of d3web.Train

d3web.Train allows the teaching faculty to create a new case using an authentic patient dismissal record by editing it with little additional information in a standard text system (for example Microsoft Word) [4]. The dismissal record should contain the final diagnoses and the names and results of all tests. The record was edited by going over the text (e.g. erasing all personal patient data) and by adding tutoring information:

- a short case introduction,
- intermediate diagnoses based on partial information about the case,
- a list of diagnoses, from which the student has to choose the right intermediate and final ones (part of them are shown in fig. 1, upper screen, left side),
- digital images of test results as blood and bone marrow smears and questions regarding these images (an example is shown in the lower screen in fig. 1),
- a final pedagogical case discussion explaining important aspects of the case.

The edited record is downloaded via a web interface into d3web.Train, which automatically generates a case presentation as shown in fig. 1. The total amount of time for case editing per case was about 6 hours: 4 hours for editing the case records as mentioned above; 2 hours for using the program and checking the case due to minor technical problems. Under optimal circumstances, the affordable time to create a case might be even shorter.

The training system

To support the education in hematology, which is part of the classes in internal medicine (students in their third and fourth year of medical school), 17 training cases were created.

Our training system covered the following diagnoses:

case 1: Hodgkin's disease
case 2: anemia due to iron deficiency
case 3: pernicious anemia
case 4: hemolytic anemia
case 5: aplastic anemia
case 6: follicular B-cell lymphoma
case 7: idiopathic thrombocytopenic purpura
case 8: myelodysplastic syndrome
case 9: osteomyelosclerosis
case 10: multiple myeloma
case 11: thrombotic thrombocytopenic purpura
case 12: common acute lymphoblastic leukemia
case 13: chronic lymphatic leukemia
case 14: chronic myeloid leukemia
case 15: hairy cell leukemia
case 16: promyelocytic leukemia
case 17: secondary acute myeloid leukemia

The topics of the 7 lectures in hematology and the assignment to the cases were:

- introduction and overview (one lecture)
- anemia (two lectures; relevant cases: 2, 3, 4, 5, 11, 12)
- myeloproliferative/myelodisplastic disorders (one lecture; relevant cases: 8, 9, 14)
- indolent Non Hodgkin's lymphoma (one lecture; relevant cases: 6, 10, 13)
- acute leukemia (one lecture; relevant cases: 12, 16, 17)
- Hodgkin's disease and aggressive Non Hodgkin's lymphoma (one lecture; relevant case: 1)

At the beginning of the lectures in hematology, all students were given a 10 minutes-long presentation on the training system together with a sheet of paper containing a short description and a personal but anonymous account. The students were asked to fill in two online questionnaires during their work with the training system: one question for each case and one question for the training system at all. 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 two times, we used the answer regarding the first questionnaire of each student and do not report on the second one (although there is as expected a slight enhancement in the grades).

At the end of the teaching period, every student had to take an exam in internal medicine. Hematology was part of the exam and was presented by ten multiple choice questions. Five of these questions were “case-oriented”. For example, we showed some key symptoms of a patient and asked for the most reasonable diagnosis. In addition, as a voluntary question, we asked the students the number of internet cases they had processed (the answer alternatives of this question were: 0, 1-5, 6-10, and 11-17). This voluntary question was necessary, because we could not correlate the statistics of the training system with the individual results in the exams, since students received an anonymous internet account for the case system (fig. 2). Not all students answered the additional question in the exam, probably due to lack of time during the exam.

Results

About 150 students attended the course and got direct access to the training system. Until the end of the course 47 students worked through at least one case and solved 435 cases in total. In average, these students processed 9.5 cases. The distribution is shown in fig. 2 (for example 8 students solved all 17 cases). For working through one case, students needed 6 minutes in average with a high standard deviation of 6 minutes (without reading the final pedagogical case discussion). These data were extracted from a log-protocol of the sessions. 18 different students filled in the questionnaire about the training system (38% of the 47 students) and 68 questionnaires were filled about the individual cases (16% of the processed cases). From 84 students (39% male, 61% female) of the course who participated in the examination, 34 did not

answer the question on the number of cases they had solved. From the remaining 50 students we were able to correlate the number of solved cases with their examination results.

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

Fig. 3 shows the opinion of the students regarding the training system as a whole. Ratings were between very good (1) and very bad (5) on a scale from 1-5 (for two questions even 1-6). The best grade was received by the question on the training system being a useful complement to conventional learning (1.17). The students intend to work further with the program (1.22). They value the training program as a whole with 1.44 and the scenario as supplement to the course as 1.28. The optical presentation of the program was perceived as very good (1.33). The judgments for the initial skill adaptation for getting used to the program ("orientation"), as for the usability, as for the learning effect were each 2.0 (fig. 3).

In addition to the evaluation of the training system as a whole, we asked for an individual judgment of each case and received 67 answered questionnaires. The helpfulness of the cases was rated quite well (1.54). The difficulty of the cases was rated as adequate by 67%, too difficult by 21%, and too easy by 12%.

Students received a feedback not only after solving a case, but also during processing the case when entering intermediate diagnoses. This feedback is generated by a comparison with the intermediate or final diagnoses of the training system entered by the case author. The quality of the system feedback during processing the case was rated as fair by 53.7%, too good by 4.5%, too bad by 37.3% and totally inadequate by 4.5%.

The third part of our evaluation correlates the number of processed cases with the results of the hematological part in the final exam of internal medicine. Details are shown in fig 4. Those 16 students, who answered that they had solved 6-17 cases (56% female, 44% male) scored at an average 8.8 out of 10 possible points. This is significantly better (two-sided t-Test, $p < 0.01$) in the hematological part of the exam, compared to those 34 students who answered that they solved 0-5 cases (65% female, 35% male) with an average score of 7.9 points. Another set of 34

students (59% female, 41% male) who did not answer the question on the number of cases they solved, scored equivalent to those who solved 0-5 cases.

Discussion

In this paper we introduced a new case-based training program in general hematology, which we offered to our students as voluntary supplement to the lectures in internal medicine. We evaluated the opinion of the students regarding the training system as a whole, the individual cases and the objective correlation between the use of the training system and the grades of our students in the hematology part of the final exam in internal medicine.

The program was very well accepted by our students. Our evaluation showed grades of 2.0 and better in a scale from 1 to 5 for all investigated features of the system. We received the best grades for the program as a whole (1.44), its design (1.33) and the intended future use (1.22). These data indicate a high satisfaction of the students with the training system in general. This result is in accordance with other studies about medical case-based training programs, as for example training programs in pediatrics [11], surgery [14], rheumatology [4] or other medical fields [12]. To our knowledge, case-based training programs have only been used for the differential diagnosis in anemia, but not in general hematology. We think hematology is a very good object to teach in a case based training system, since we are able to combine digital imaging of blood- and bone marrow smears with history, physical examination and laboratory tests of a patient. The positive judgment of our students supports this hypothesis.

It is also supported by the observation that students solving more than 5 cases scored significantly better in the final exam than those solving less than 6 cases (8.8 versus 7.9 points from 10 in average). Of course, this observation is only a hint to the effectiveness of the training system: the correlation is based on a rather low number of students. In addition, we do not know the exact causalities: Do only the smart and ambitious students work through the training system or does processing the cases make the students better? A surprising result is, that those few students processing 1-5 cases scored worst in the examination (7.4 points), even worse than those processing no cases at all (8.0). However this is not significant due to low numbers. If this tendency persists in future evaluations, we will test the hypothesis, that they had difficulties with

solving the cases (as regards either to technique or to content) and soon gave up, which is – if it is their general attitude to learning – not very effective.

A further critical factor for assessing case-based training systems is the development time for the authors. Lesser the amount of time needed to create the case system, more flexible it is. The lecturer is able to customize the training system according to his or her special favors and is even able to show the same cases in the lectures, as in the training system. Students missing lectures are able to keep up by solving the cases in the training system whenever they want.

While authoring of case-based training systems until now needed an enormous amount of time, case authoring with d3web.Train needed only up to 6 hours in average per case due to reuse of case dismissal records [4], thus enabling the authors to create the whole training system in a few weeks.

Time is a matter of interest, not only for the authors, but also for the medical students. They must balance their available time budget for learning. Therefore they can not invest too much time in any one of the subjects. Working through the training system may take time, depending on the amount of background information which is integrated into the system. Since students could learn the diseases in lectures and textbooks as well, it is difficult to assess how much background information in case studies is adequate: for some students, it may be too short, for others too detailed. Therefore we decided to separate the case from the background information. Background information is only available as an option, but not integrated into the case. The student who simply wants to test his or her diagnostic skills can process a case quite fast. This separation seems to be well accepted by the students, who needed only 6 minutes in average to process a case. The fast processing time resulted in a high percentage of processed cases. This is in contrast to other case based training systems, which we mentioned above. Evaluation of these systems revealed for example an average time to process a case of 43 minutes [12]. Therefore students processed only few cases in average [12].

In summary, the novel d3web.Train system enables the academic teacher to generate a fast and flexible case-based training system. The training system in hematology in addition to conventional teaching methods is welcomed and very well accepted by students. Processing of cases takes a relatively small amount of time, encouraging the students to solve many cases. We

are planning to integrate our training system into a new skills-laboratory in the medical facility in Würzburg, which offers the students the opportunity use the system whenever they want. Furthermore, training systems in other specialties as for example rheumatology and dermatology are offered to our students. In addition the authoring component of d3web.Train should be used for the creation of more training cases in hematology, not only for the education of medical students, but also in the education of physicians in residency.

Acknowledgements

This work has been supported by grants of the BMBF (08NM 111A) in the project CASEPORT [15].

References

1. Afrin LB (1999) Web access to the American Society of Hematology slide bank. Blood 93:2425-2426

2. Birndorf NI, Pentecost JO, Coakley JR, Spackman KA (1996) An expert system to diagnose anemia and report results directly on hematology forms. Comput Biomed Res 29:16-26

3. Diamond LW, Tamino PB, Seal AH, Nguyen DT (1995) Multiparameter case studies using knowledge-based systems in hematology. Comput Methods Programs Biomed 48:59-64

4. Hörnlein A, Reimer S, Kneitz C, Betz C, Puppe F (2004) Semantische Annotierung von Arztbriefen zur Generierung diagnostischer Trainingsfälle. In: Engels, G. and Seehusen, S. (Hrsg.): DeLFI 2004: Die 2. e-Learning Fachtagung Informatik, Springer Berlin Heidelberg New York, 247-258.

5. Huret JL, Dessen P, Bernheim A (2001) Atlas of Genetics and Cytogenetics in Oncology and Hematology, updated. Nucleic Acids Res 29:303-304

6. Lyon HC Jr, Healy JC, Bell JR, O'Donnell JF, Shultz EK, Wigton RS, Hirai F, Beck JR (1991) Significant efficiency findings while controlling for the frequent confounders of CAI research in the PlanAlyzer project's computer-based, self-paced, case-based programs in anemia and chest pain diagnosis. J Med Syst 15:117-132

7. Moura AA, Lhano MG, Del Giglio A (2000) Education via the Internet: preliminary experience of the hematology-oncology discipline of the ABC Foundation School of Medicine. Rev Assoc Med Bras 46:47-51

8. Nguyen A, Wu S, Jalali M, Uthman M, Johnson K, Banez E (2001) A web-based database for diagnosis of hematologic neoplasms using immunophenotyping by flow cytometry. Med Inform Internet Med 26:309-323

9. Riley RS, Ben-Ezra JM, Massey D, Cousar J (2002) The virtual blood film. Clin Lab Med 22:317-345

10. Riley RS, Ben-Ezra JM, Massey D, Slyter RL, Romagnoli G (2004) Digital photography: a primer for pathologists. J Clin Lab Anal 18:91-128

11. Ruderich F, Riedel J, Singer R, Heid J, Bauch M, Leven FJ, Köpf S, Seidel C, Tönshoff B, Starkloff P, Reimann P (2002) CAMPUS in der Praxis - Evaluation im Rahmen eines pädiatrischen Praktikums. In: Bernauer J, Fischer MR, Leven FJ, Puppe F, Weber M (eds) Rechnergestützte Lehr- und Lernsysteme in der Medizin. Proceedings zum 6. Workshop der GMDS AG. Shaker, Aachen pp 87-96

12. Simonsohn A, Fischer M(2004) Evaluation eines fallbasierten computergestützten Lernsystems (CASUS) im klinischen Studienabschnitt. Deutsche Medizinische Wochenschrift 129:552-556.

13. Woermann U, Montandon M, Tobler A (1998) HemoSurf - an interactive hematology atlas on the world wide web. Schweiz Med Wochenschr 128:1605-1607

14. Zumbach J, Mehrabi A, Schwarzer H, Rentz C, Reimann P, Herfarth Ch & Kallinowski F (2000) Wie beurteilen Studierende CBT-Module? Evaluation von Trainingsprogrammen in der Chirurgie. In: Koop A, Novak D (eds) CBT in der Medizin. Shaker, Aachen, pp 113-125

15. http://www.caseport.de, Aug. 2004

16. http://www.d3webtrain.de, Aug. 2004

Legends

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

fig. 2: The distribution of the number of processed cases per student (n = 47)

fig. 3: subjective opinion of the students (n = 18) about the training system (mean and standard deviation)

fig. 4: Average score in the final examination (MC-test) depending on the number of processed cases per student (n = 50; mean and standard deviation)