

CASE-BASED E-LEARNING IN OCCUPATIONAL MEDICINE – THE NETWoRM PROJECT IN GERMANY

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Abstract: The aim of the NetWoRM Project is the development, evaluation and implementation of a case-based e-learning tool for occupational medicine to increase the knowledge in clinical aspects of occupational medicine. To date, 19 e-learning cases have been developed. Cases were validated by 2 experts and user evaluated. Results of the user evaluation at 3 German Medical Schools are presented. Of 557 medical students registered for the online course 377 answered the online evaluation form (68%). Depending on the case, the median time spent on a case ranged from 25–43 minutes. Students enjoyed working with the cases and asked to replace more seminars by case-based e-learning. The level of knowledge required to work on the cases was rated high. This was supported by the fact that on median only 47–71% of the questions were answered correctly. Cases focusing on occupational health problems such as needle stick injuries were rated highest with respect to fun, importance for future career and the overall score. Students enjoy working on e-learning cases as an add-on to traditional teaching. Because of the high international interest the NetWoRM project is currently shared on an international base.

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INTRODUCTION

A survey from the United Kingdom has shown that for people working in the last 12 months the annual prevalence of diseases caused or made worse by work is about 4.6% [4]. Therefore, occupational influences have to be considered as causes for many diseases like asthma, carcinomas, musculoskeletal diseases, and intoxications throughout Europe. As a result, occupational factors have

to be taken into account by physicians in many disciplines. In order to prevent and recognize occupational diseases, medical students should learn about the potentially causal relationship between profession and diseases as well as the basic legal aspects of occupational medicine (OM). Therefore, OM is a compulsory subject in the medical curriculum in many countries.

In a recent review Littlewood *et al.* have shown that early practical experience helps medical students to learn

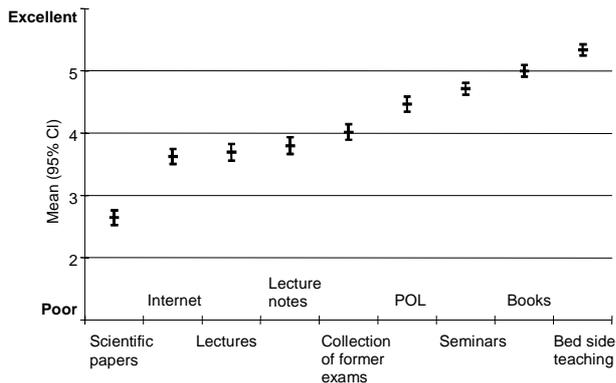


Figure 1. Effectiveness of different learning methods rated by 5th year medical students in Munich (n=502).

and to understand [6]. In accordance with these findings we have found that medical students rate medical clerkships (= bedside teaching) the most efficient way to learn medicine (Fig. 1). Therefore, in Germany many clinical specialities have recently increased the amount of bedside teaching in medical training. However, the opportunity of bedside teaching in OM is limited as most medical schools with occupational departments only have an outpatient clinic. This might be one reason why medical students rate their interest in, importance of and knowledge about OM low [5]. The latter has been supported by a study by McCurdy *et al.* showing that only about 70% of 3rd year medical students take an occupational history [9].

In Germany, teaching in OM at the undergraduate level is often carried out during lectures combined with seminars and sometimes workplace visits. More recently, problem oriented approaches, such as paper cases, have been included. In addition, multimedia material, e.g. movies, is used at some medical schools. So far, distance learning has not been available for occupational medicine in Germany. In other countries like the UK, US and Canada distance learning is common, especially for post-graduate training of occupational physicians and hygienists [1] (<http://www.mcgill.ca/occh/distance/>). To our knowledge, none of these tools so far included case-based e-learning which might come closer to the practical aspects of OM than online texts or paper-based cases. Case-based e-learning has been implemented into teaching in other clinical specialities. This approach resulted in higher motivation of the students to learn, improvement in the learning process as well as in the problem-solving ability (e.g., [8, 11, 12]).

Therefore, in 1999 we started to develop a case-based e-learning tool for occupational medicine (NetWoRM – Netbased Training in Work-Related Medicine) [5]. The overall aim of NetWoRM is to enhance the interest of undergraduate students in OM as well as to increase the practical aspects in the training of physicians in postgraduate training using problem-based learning with interactive multimedia e-learning cases.

In the beginning, these cases were created in HTML. Since then, we have implemented them into the CASUS

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- a) Cases related to occupational health hazards in health care workers
- Needle stick injury in a medical student[#]
 - Tuberculosis in a healthcare worker[#]
 - Medical clerkship in nuclear medicine[#]
 - Nurse with hand eczema, rhinitis, conjunctivitis and asthma*
- b) Cases related to chemical hazards at work
- Bakers' asthma[#]
 - Lead intoxication[#]
 - Pleura mesothelioma from the patients' point of view[#]
 - Occupational handling of tar[#]
 - Worker with dyspnea and cough (asbestosis)*
 - Nasal septum perforation of a chromium-plater*
 - Liver cirrhosis in a farmer*
- c) Cases related to physical hazards
- Skin tumours in a street worker[#]
 - Noise induced hearing loss*
- d) Cases related to ergonomics
- White fingers in a forestry worker*
 - Carpal tunnel syndrome*
- e) Cases related to social aspects of work and other areas
- Flight attendant with diabetes mellitus 1[#]
 - Occupational screening in miners[#]
 - Workplace accident*
 - Occupational epidemiology*
-

[#] Cases included and user evaluated in the current course

* Cases included and user evaluated in previous courses

+ Cases currently under expert review and therefore not yet included in the curriculum

Figure 2. Web-based cases currently available for occupational medicine in Germany.

system (INSTRUCT AG www.instruct.de [3]). Cases have been used in tutor guided seminars in our computer lab [5], in lectures, as well as in blended learning approaches combining lectures and seminars with an online course. In this paper we present the cases currently available as well as the evaluation results of our online course for undergraduate medical students.

METHODS

The CASUS system. Cases have been created using the CASUS authoring system. The major advantage of this system is its easy to use interface so that the cases can easily be created by an author without in-depth knowledge of computer programming. Movies and pictures can comfortably be implemented into the programme. All CASUS components are web based. Therefore, the cases can be created, evaluated and used at any computer with an Internet connection using a standard Internet browser (Netscape, Internet Explorer, ...). Authors and users need login and password to enter the cases. The course manager gives the possibility to evaluate students' success (time worked on a case, percentage of questions answered correctly, number of screens worked on, etc.).

Case creation. Overall, 19 cases (Fig. 2) have so far mainly been developed by residents in training for OM and by students doing their medical thesis at our unit. The cases cover mainly 4 traditional areas of occupational medicine: chemical hazards, physical hazards, ergonomics and social aspects as well as an introduction into occupational epidemiology. In addition, in order to meet

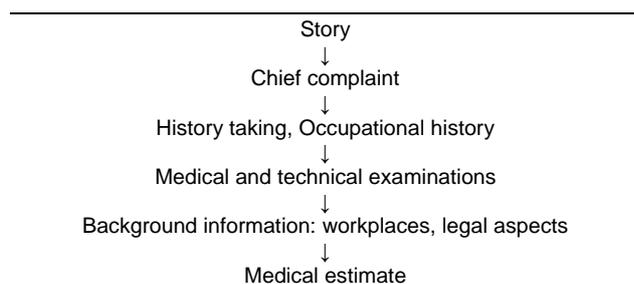


Figure 3. Structure of the web-based cases.

the specific needs of undergraduate teaching 4 of the cases focus on occupational hazards in the health care setting. Based on our experience, cases based on the history of real patients are considered most useful. Therefore, the cases have been created using material from patients of the outpatient departments for occupational medicine at the universities in Munich, Erlangen, Hamburg, Mainz, Halle and Jena (Germany).

The content of the cases is created according to the clinical procedure every medical student needs to know (Fig. 3). In addition to the main structure the student can access background information by clicking on an "expert button", hyperlinks or links to external web pages. The use of questions in different formats (multiple choice, sorting, free text entry) and detailed answer comments provide additional interactive features. Wherever possible, video sequences and pictures enhance the visualisation of the problems presented (for an example in English see www.networm-online.net/demo.html).

Expert evaluation. Each of the cases has been expert evaluated by at least 1 expert in occupational medicine involved in the project (internal review) as well as 1 expert not directly involved (external review). Cases related to other clinical specialities have also been evaluated by experts of the respective field, e.g., the case on lead intoxication has been evaluated by a surgeon and an internist, the case on diabetes mellitus type 1 in a flight attendant has been expert evaluated by a diabetes educator. For expert evaluation a paper version of the cases has been shown to be helpful. After the experts' recommendations have been implemented the cases are presented to the students for pilot testing.

Implementation of the cases into teaching. During the summer term 2005, 10 of the cases have been used in the course for occupational medicine at 10 of the 37 German medical schools.

Previous evaluation results had indicated that students prefer distance training on the cases over tutor guided training within seminars. Therefore, students worked on the cases at the place of their convenience (e.g., computer lab, home). To log onto the cases they obtained login and password from their course manager.

User evaluation. During summer term 2005, student evaluation of the cases was carried out at 3 medical

schools (Munich, Regensburg, Erlangen). At these schools occupational medicine is offered during the 7th semester (Munich) or 8th semester (Regensburg, Erlangen). The students had to work on any 2 of the 10 cases. In addition to this online course, lectures and small group seminars as well as site visits to workplaces were offered. The success of the students was evaluated based on the time spent on each case, the percentage of correct answers to questions as well as the number of screens the students worked on. These data are automatically saved in the session data after each login.

After completion of the case the students were asked to fill-in a 1-page online evaluation form. Items included user satisfaction (fun, efficiency), importance of the case content for their future job, difficulty of the case content, motivation to use such e-learning cases and overall rating of the e-learning course. All items were assessed on a 6 point Likert scale ranging from "completely agree" to "completely disagree". The overall rating was assessed on a 15 point scale from "poor" (1) to "excellent" (15).

Additionally, the type of internet access used for each session was assessed (modem, LAN, broadband).

Statistical analyses. Students were considered to have worked on a case if they had spent at least 10 minutes on the case and completed more than 10 screens. Median, lower and upper quartiles of the time spent on each case, % of correct answers and number of screens worked on are reported stratified for case.

The evaluation forms were obtained electronically from the questionnaire server. Analyses were also performed stratified for case. Results are presented as mean with 95% confidence interval as well as relative frequency. In addition, statistical significance was tested using analyses of variance. A p -value < 0.05 was considered statistically significant.

RESULTS

Overall, 557 students registered for the online course. Of these, 528 completed the required number of at least 2 online cases (96%). Half of the students completed at least 3 cases, 11% went through all 10 cases.

377 students (68%) filled-in at least 1 online evaluation form. Overall, 737 online evaluation forms were completed. The larger number of evaluation forms compared to the number of students is due to the fact that more than 1 case could be evaluated. For the majority of sessions (54%) broadband Internet connections outside the university were used, 32% worked in local networks. Only 14% used modems to work on the cases.

Objective measures. As shown in Table 1, more than 80% of the students worked on the case telling the story of a needle stick injury in a medical student. All other cases were used by 24% (medical screening in miners) to 48% (lead intoxication) of the students. The higher number of students working on the needle stick injury and

Table 1. Results of the log file on time spent on cases, number of screens completed and % of correct answers stratified by case.

N = 557	Screens	Users	Time spent on the case (min)	% of correct answers	n screens completed
	n	n (%)	Median (25th; 75th Quartile)		
Tuberculosis in a MS	22	199 (35.7)	25 (18; 38)	71 (61; 77)	22 (22; 22)
Needle stick injury in a MS	25	447 (80.3)	43 (30; 60)	63 (55; 69)	25 (25; 25)
Clerkship in nuclear medicine	19	160 (28.7)	27 (19; 39)	58 (47; 67)	19 (19; 19)
Pleuramesothelioma	22	214 (38.4)	25 (16; 36)	49 (35; 61)	22 (22; 22)
Lead intoxication	33	265 (47.6)	38 (27; 58)	70 (62; 78)	33 (33; 33)
Bakers' asthma	31	215 (38.6)	38 (25; 62)	63 (54; 70)	31 (31; 31)
Handling of tar	25	160 (28.7)	36 (23; 55)	69 (62; 75)	25 (25; 25)
Skin tumours	20	144 (25.9)	40 (26; 58)	57 (47; 64)	20 (20; 20)
Flight attendant with DM-1	23	207 (37.2)	37 (24; 56)	47 (40; 53)	23 (23; 23)
Medical screening	23	136 (24.4)	27 (20; 41)	52 (43; 62)	23 (23; 23)

MS = medical student; DM-1 = diabetes mellitus type 1

the lead intoxication may result from the fact that these 2 cases were the first showing up in the list of 10 cases. The majority of students completed all screens in all of the cases. On median, students spent between 25–43 minutes working on the cases. Correct answers were on median given to 47% of the questions (flight attendant with diabetes mellitus type 1) up to 71% of the questions (tuberculosis in a medical student).

Evaluation results. On average, students filling-in the questionnaires enjoyed working on the cases and considered them important for their future career (Tab. 2). The evaluation results for the single cases differed significantly with respect to fun ($p < 0.0001$), efficiency ($p < 0.0001$), and importance of case content for future job ($p < 0.0001$). The overall rating of the cases differed slightly but significantly ($p = 0.03$).

Cases related to their own profession, especially the needle stick injury and the tuberculosis in medical students, were rated highest. While the tuberculosis in a medical student was rated highest with respect to fun and efficiency as well as the overall rating, the importance of the needle stick injury was considered higher than the case on tuberculosis (n.s.). The case with the lowest scores was the skin tumour in a construction worker.

Irrespective of the case content the students rated the level of knowledge needed to complete the cases high. Also independent of the case content the student asked to replace more seminars by case-based e-learning (3 instead of 2). Adjusting our analyses for gender or medical school did not change the results (data not shown).

DISCUSSION

To date, 19 interactive e-learning cases for occupational medicine have been developed. Most of them have already been expert validated and user evaluated. The cases are continuously kept up to date and can be used during tutor guided seminars [5] as well as in self-study.

The session data have shown that most students actually worked thoroughly on the cases. The majority completed all screens and spent about 30 minutes per case. As the cases are not directly comparable due to different number of screens and different level of knowledge required to answer the questions we did not analyse whether the results differed significantly between the cases.

Most students completed more than the required number of 2 cases, 10% even worked successfully on all cases. This finding is supported by the evaluation results indicating that students enjoyed working on the cases. In addition, students considered the cases important for their career.

In accordance with this, students indicated that they would like to substitute more seminars by case-based e-learning. At the time of the survey, 2 of the traditional seminars were replaced by case-based e-learning. On average, they asked to replace 3 instead of 2 seminars by case-based e-learning. Nevertheless, most students indicated that the cases were an important add-on but no replacement of traditional teaching in the classroom. This aspect has been shown earlier [10, 14] and should not be forgotten when planning case-based e-learning.

A large number of students filled-in the online evaluation form. Therefore, our results are thought to be representative for the students at the 3 universities under study. Regarding the statistical analyses one has to bear in mind that most students completed two evaluation forms. Therefore, the observations are not completely independent. This has to be taken into account interpreting the results of the analyses of variances. In addition, only about one quarter to one third of the students who worked on a specific case actually filled in an evaluation form for this case. One reason might be that students thought that they had to fill-in evaluation forms for the required 2 cases only. Therefore, selection bias should not be a major problem.

It is interesting to note that more than 80% of the students worked on the case of the needle stick injury in a

Table 2. Evaluation results stratified by case. Unless otherwise stated cases have been evaluated on a Likert scale from 1= completely agree to 6 = completely disagree.

	n	mean	95%-CI of x		PANOVA		n	mean	95%-CI of x		PANOVA
			Lower Limit	Upper Limit					Lower Limit	Upper Limit	
Working on the case...						I would like to work on the cases in... out of the six					0.33
...was fun					<0.0001	obligatory seminars					
Tuberculosis in a MS	48	1.94	1.44	2.43		Tuberculosis in a MS	47	3.49	2.70	4.28	
Needle stick injury in a MS	234	2.18	1.96	2.41		Needle stick injury in a MS	216	2.82	2.46	3.19	
Clerkship in nuclear medicine	56	2.52	2.06	2.98		Clerkship in nuclear medicine	48	2.90	2.11	3.68	
Pleuramesothelioma	62	2.48	2.05	2.92		Pleuramesothelioma	59	3.17	2.46	3.87	
Lead intoxication	74	2.19	1.79	2.59		Lead intoxication	72	3.15	2.51	3.79	
Bakers' asthma	68	2.47	2.05	2.89		Bakers' asthma	65	3.43	2.76	4.10	
Handling of tar	51	2.31	1.83	2.80		Handling of tar	50	3.28	2.51	4.05	
Skin tumours	44	3.20	2.69	3.72		Skin tumours	42	3.17	2.33	4.00	
Flight attendant with DM-1	61	2.56	2.12	3.00		Flight attendant with DM-1	60	3.12	2.42	3.82	
Medical screening	45	2.69	2.18	3.20		Medical screening	44	3.36	2.55	4.18	
...was efficient					<0.0001	Overall rating of the case on a scale from 0 to 15					0.03
Tuberculosis in a MS	48	2.15	1.65	2.65		Tuberculosis in a MS	48	10.81	9.46	12.17	
Needle stick injury in a MS	234	2.40	2.17	2.62		Needle stick injury in a MS	229	10.11	9.49	10.73	
Clerkship in nuclear medicine	55	2.69	2.22	3.16		Clerkship in nuclear medicine	54	9.06	7.78	10.33	
Pleuramesothelioma	63	2.71	2.28	3.15		Pleuramesothelioma	62	9.92	8.73	11.11	
Lead intoxication	74	2.32	1.92	2.73		Lead intoxication	73	10.22	9.12	11.32	
Bakers' asthma	68	2.62	2.20	3.04		Bakers' asthma	67	9.69	8.54	10.83	
Handling of tar	51	2.16	1.67	2.64		Handling of tar	51	10.43	9.12	11.75	
Skin tumours	44	3.25	2.73	3.77		Skin tumours	44	8.48	7.06	9.89	
Flight attendant with DM-1	61	2.74	2.29	3.18		Flight attendant with DM-1	60	9.70	8.49	10.91	
Medical screening	45	2.69	2.17	3.20		Medical screening	45	10.00	8.60	11.40	
I consider the case content important for my career					<0.0001						
Tuberculosis in a MS	48	2.23	1.75	2.71							
Needle stick injury in a MS	228	1.96	1.73	2.18							
Clerkship in nuclear medicine	54	2.70	2.25	3.16							
Pleuramesothelioma	63	2.32	1.89	2.74							
Lead intoxication	75	2.64	2.25	3.03							
Bakers' asthma	66	2.68	2.27	3.09							
Handling of tar	50	2.56	2.09	3.03							
Skin tumours	44	2.75	2.24	3.26							
Flight attendant with DM-1	61	2.62	2.19	3.05							
Medical screening	45	2.67	2.17	3.17							
The level of knowledge required for the case was too low (1) ... too high (7)					0.64						
Tuberculosis in a MS	48	5.06	4.57	5.55							
Needle stick injury in a MS	231	4.84	4.62	5.07							
Clerkship in nuclear medicine	54	5.04	4.58	5.50							
Pleuramesothelioma	62	4.84	4.41	5.27							
Lead intoxication	74	4.81	4.42	5.20							
Bakers' asthma	67	5.10	4.69	5.52							
Handling of tar	50	4.96	4.48	5.44							
Skin tumours	44	5.14	4.63	5.65							
Flight attendant with DM-1	61	5.08	4.65	5.52							
Medical screening	45	5.00	4.50	5.50							

MS = medical student; DM-1 = diabetes mellitus type 1

medical student that appeared first on the list of cases. Therefore, during the following semesters the order of the cases should be changed from time to time or the cases should be given at random order.

We unfortunately have no data whether working on the cases also improves the learning outcome or makes students to think more about occupational causes of disease in their future work. A prospective study would be necessary to prove this concept. As many factors influence whether physicians take occupational exposures into account, working on 2 cases can only contribute little counts. Our evaluation results also indicate that content of the cases does matter. Cook and Dupras [2] recently summarized that developing effective web teaching is more than putting together a colourful webpage. They pointed out that developing effective web-based learning requires thought and planning as does any other teaching. This can be seen by the fact that medical students rated the case of skin cancer in a construction worker significantly lower than the case on a needle stick injury. The reason for this might be that most of the students were in the 7th or 8th semester, while dermatology is taught during the 9th and 10th semester. Therefore, they were lacking the basis for this case. At the same time our results show that students are much more likely to enjoy

working on cases related to their own profession. However, the case of radiation protection in nuclear medicine was not rated as high as the other 2 cases in the healthcare setting. The reason for this might be that radiation protection is largely theoretical and does not have as many clinical features.

Due to our positive experiences with the e-learning cases, the cases are currently translated into other languages, adapted to other medicolegal systems and used in other countries. In Germany we have already started to use them as part of the postgraduate training in occupational medicine and plan to integrate them in continuing medical education. In this context it has been shown that doctors in postgraduate training are more satisfied with problem based learning [13]. For this approach some of the cases have to be adapted to the higher level of knowledge by physicians in postgraduate training. However, our previous experience indicates that even physicians preparing for their specialisation exam find working on the cases helpful.

So far, our cases mainly cover the traditional aspects of occupational health. However, these aspects are still seen as the core requirements for occupational medicine training in Europe [7]. In the context of the a.m. international project new cases are being developed focusing on psychosocial aspects of work, vulnerable subgroups, as well as smoking, alcohol and drugs at work. Finally, we are currently working on cases for secondary school students in order to inform them about the associations between work and health. This might enable them to make an informed choice when selecting their future job (www.inqa.de).

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REFERENCES

1. Burgess G, Holt A, Agius R: Preference of distance learning methods among post-graduate occupational physicians and hygienists. *Occup Med (Lond)* 2005, **55**, 312-318.
2. Cook DA, Dupras DM: A practical guide to developing effective web-based learning. *J Gen Intern Med* 2004, **19**, 698-707.
3. Fischer MR: CASUS - An authoring and learning tool supporting diagnostic reasoning. *Z Hochschuldidaktik* 2000, **1**, 87-98.
4. *Health & Safety Executive*. Self-reported work-related illness in 1998/99: results from the EUROSTAT ill-health module 1999 Labour Force Survey summer quarter. London 2000.
5. Hege I, Radon K, Dugas M, Scharrer E, Nowak D: Web-based training in occupational medicine. *Int Arch Occup Environ Health* 2003, **76**, 50-54.
6. Littlewood S, Ypinazar V, Margolis SA, Scherpbier A, Spencer J, Dornan T: Early practical experience and the social responsiveness of clinical education: systematic review. *BMJ* 2005, **331**, 387-391.
7. Macdonald EB, Ritchie KA, Murray KJ, Gilmour WH: Requirements for occupational medicine training in Europe: a Delphi study. *Occup Environ Med* 2000, **57**, 98-105.
8. Maleck M, Fischer MR, Kammer B, Zeiler C, Mangel E, Schenk F, et al.: Do computers teach better? A media comparison study for case-based teaching in radiology. *Radiographics* 2001, **21**, 1025-1032.
9. McCurdy SA, Morrin LA, Memmott MM: Occupational history collection by third-year medical students during internal medicine and surgery inpatient clerkships. *J Occup Environ Med* 1998, **40**, 680-684.
10. Riley JB, Austin JW, Holt DW, Searles BE, Darling EM: Internet-based virtual classroom and educational management software enhance students' didactic and clinical experiences in perfusion education programs. *J Extra Corpor Technol* 2004, **36**, 235-239.
11. Shokar GS, Bulik RJ, Baldwin CD: Student perspectives on the integration of interactive Web-based cases into a family medicine clerkship. *Teach Learn Med* 2005, **17**, 74-79.
12. Simonsohn AB, Fischer MR: [Evaluation of a case-based computerized learning program (CASUS) for medical students during their clinical years]. *Dtsch Med Wochenschr* 2004, **129**, 552-556.
13. Smits PB, Verbeek JH, de Buissonje CD: Problem based learning in continuing medical education: a review of controlled evaluation studies. *BMJ* 2002, **324**, 153-156.
14. Valcke M, De Wever B. Information and communication technologies in higher education: Evidence-based practices for medical education. **In:** AMEE 2005; Amsterdam: RAI 2005.