Interactive e-learning courses in human genetics: Usage and evaluation by science and medical students at the faculty of medicin

Abstract

Introduction: This study presents our online-teaching material within the k-MED project (Knowledge in Medical Education) at the university of Marburg. It is currently organized in five e-learning modules: cytogenetics, chromosomal aberrations, formal genetics, fundamentals of molecular diagnostics, and congenital abnormalities and syndromes. These are basic courses intended to do the educational groundwork, which will enable academic teachers to concentrate on more sophisticated topics during their lectures.
Methods: The e-learning modules have been offered to a large group of about 3300 students during four years at the Faculty of Medicine in Marburg. The group consists of science students (human biology) and medical students in the preclinical or the clinical period, respectively. Participants were surveyed on acceptance by evaluating user-tracking data and questionnaires.
Results and Conclusion: Analysis of the evaluation data proofs the broad acceptance of the e-learning modules during eight semesters. The courses are in stable or even increasing use from winter term 2005/06 until spring term 2009.
Conclusion: Our e-learning-model is broadly accepted among students with different levels of knowledge at the Faculty of Medicine in Marburg. If the e-learning courses are maintained thoroughly, minor adaptations can increase acceptance and usage even furthermore. Their use should be extended to the medical education of technical assistances and nurses, who work in the field of human genetics.

Keywords: Human genetics, e-Learning, evaluation, multimedia

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Introduction

k-MED (Knowledge in Medical Education) is an independent internet based learning platform designed for undergraduate or continuing biomedical education. Together with ist predecessors k-MED has been continuously sponsored by the Ministry of Science and Arts of the state of Hessia from 1999 until termination of funding in 2009. From January 2001 up to April 2004 it was additionally supported by a grant from the German Federal Ministry of Education and Research (BMBF) within the support program “New Media in Education”. Meanwhile k-MED has been established as a new institution at the medical deaneries of Hessian Justus-Liebig and Philipps university. It evolved from a single medical subject project to a service provider of comprehensive technology and content for authors and learners [1]. The platform is based upon the sophisticated open source learning management system (LMS) ILIAS (http://www.ilias.de/docu/) and provides multimedia e-learning courses, an online evalu-

ation area (for creating questions and self-assesment), an online discussion forum and online options for testing [2]. ILIAS has been developed at the university of Cologne within the VIRTUS project in 1997/1998. It aimed at improving classical learning scenarios by the means of novel information and communication technologies. ILIAS is more and more applied at universities, other educational institutions, business establishment and administrative facilities such as the German Federal Employment Office. Currently (2011), k-MED offers over 200 different e-learning courses or modules being accessed by approximately 15.000 users, of which 5000 belong to the university of Marburg. At the medical faculty of the university of Marburg and – to an increasing extent – the university of Giessen the online material is provided within a blended learning scenario supplementing the traditional study concept.

The new "Approbationsordnung für Ärzte" – a federal law regulating medical education für physicians' licensing, that has come into effect in Oct 1st, 2003 – improves the status of human genetics in medical education. On the other hand teaching staff is being challenged in many ways. Additional lectures and seminars had to be integrated into the curriculum, but personnel was rather reduced. The five e-learning modules in human genetics are not intended to replace the classical teaching units, but they aim at relieving the burden on staff by providing simple-to-use, online options for teaching/learning, testing, and communication. Furthermore, they shall compensate deficits in basic knowledge of human genetics. This rationale is supported by a study about the attitude of medical students towards human genome research at the university of Leipzig. Accordingly, human genetics has been considered as relevant, and an increasing integration of this subject into the medical curriculum has been required
[3]. Our material may not only provide a means to enhance learning efficacy, but interactions between teachers and students may also become more intensive using an online communication forum, a central storage place for scripts, links and course schedules.

Methods

Project

Actually our online-teaching material is organized in five – partially interactive - e-learning modules (see Figure 1): cytogenetics, chromosomal aberrations, formal genetics, fundamentals of molecular diagnostics, and congenital abnormalities and syndromes (see Table 1).

Table 1: Design of the five e-learning modules human genetics including kind and number of employed media types

	(1) cyto-genetics	(2) Chromo-somal aber-rations	(3) formal genetics	(4) Fun-damentals of molecular diagnostics	(5) congenital abnormalities and syndromes
pages	29	48	40	46	45
tables	0	1	7	5	4
photographs	12	11	2	1	9
graphics (not interactive)	6	14	17	20	2
interactive graphics	3	3	0	0	0
interactive questions for self testing	6	7	10	10	22

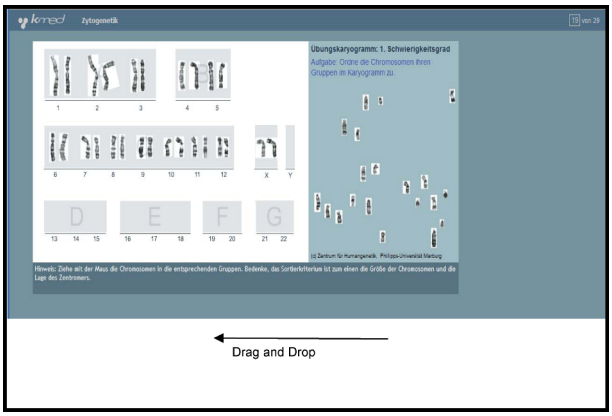


Figure 1: Example of an inteactive e-learning module: Making of an online karyogram

These are basic courses intended to supplement the traditional learning scenario. During the academic year (winter and summer term) about 750 – 800 students at the faculty of medicin attend courses in human genetics. The aforementioned e-learning modules are integrated in the canonical curriculum within the framework of a new blended learning scenario. The users comprise about 50 students of human biology, about 440 medical students at the beginning of their preclinical study period and approximately 300 medical students in their clinical period (7th – 8th semester). All students received the e-learning modules in human genetics on an explicitly **voluntary** basis (see Table 2). During the fourth semester students of human biology attend the lecture "Human Biology III (1,3 semester periods per week), while they attend the lecture and an additional seminar "Molecular Biology and Human Genetics (1 semester period per week) in the 7th and 8th semester. This relieves the burden on teaching staff, because the fundamentals of genetics can be learned at home, and teachers may focus on more specific and "interesting" aspects of human genetics.

Table 2: Integration of the e-learning modules in the curriculum of human genetics at the faculty of medicin at the university of Marburg.

teaching unit	target group	recommended e-learning modules
lc biology for medical students 4 spw (thereof 30 % human genetics): only wt	400 – 440 medical students in the preclinical study period (first semester) + approx. 60 dental students (5th preclinical semester)	(1) – (5)
pt biology for medical students 8 spw (thereof 30 % human genetics): only wt	400 – 440 medical students in the preclinical study period (first semester)	(1) – (5)
se clinical genetics 1 spw: wt + st	180 – 300 medical students in their clinical study period (7th + 8th semester)	(1) (2) (3) (5)
lc clinical genetics 1 spw: wt + st	180 – 300 medical students in their clinical study period (7th + 8th semester)	(1) (2) (3) (5)
pt basics in human biology II, 6 spw (thereof 30 % human genetics: only wt	about 50 students of human biology in the 5th semester (final degree: diploma)	(1) – (5)

lc: lecture, pt: practical training course, se: seminar, spw: semester period per week, wt: winter term, st: spring term

In principle, all groups receive the same e-learning modules, but the underlying education concept depends from the respective study course:
Students of human biology (diploma) are provided with the online material to prepare for the practical training course in human genetics and the written examination in the 5th semester. Medical students are offered the same modules to perform follow-up course work for their practical training in biology and to prepare for the exam at the end of the 1st semester. Medical students in the second (clinical) period employ the modules to recapitulate basic knowledge in human genetics from the 1st semester and to exercise themselves in clinical genetics. Since winter term 06/07 the e-learning module "congenital abnormalities and syndromes" displaces the module "fundamentals of molecular diagnostics". Congenital abnormalities and syndromes is endowed with a great number of 22 exercises for self-testing (see Table 1). The learning matter should be tested and consolidated by answering forced choice questions – one correct response out of five possible ones. The user learns from the immediate feedback on his/her answers. In case of a wrong answer the correct response together with some explanation will pop up. This is supplemented by several interactive test items with different levels of difficulty, where the learners can draw online karyograms applying the drag-and-drop technique. If the chosen chromosome is incorrectly assigned it will jump back – only in case of correct mapping the chromosome will "stick" to the respective position in the karyogram.

Evaluation of the e-learning modules in human genetics

To be surveyed on user friendliness and acceptance user-tracking data for the learning modules (number of accesses and averaged duration of access) (see Table 3 and 4) and also questionnaires (see Figure 2) were evaluated.

Table 3: Evaluation of the acceptance of the e-learning modules by user-tracking
Cumulative use at the faculty of medicine in Marburg.

	(1)	(2)	(3)	(4)	(5)*	time interval
accesses	*1289*	*1400*	*1106*	*906*		WT05/06 (n~700)
	3531	4794	3475	2374	999	WT05/06-ST07 (n~1700)
	5741	7834	8011	3645	2411	WT05/06-ST09 (n~3300)
access per user	2,5	2,7	2,3	2,2		WT05/06 (n~700)
	2,7	3,2	2,7	2,4	2,6	WT05/06-ST07 (n~1700)
	2,6	3,2	3,1	2,4	2,6	WT05/06-ST09 (n~3300)
times of use (min)	46	83	65	56		WT05/06 (n~700)
	53	105	77	66	76	WT05/06-ST07 (n~1700)
	52	105	87	60	77	WT05/06-ST09 (n~3300)

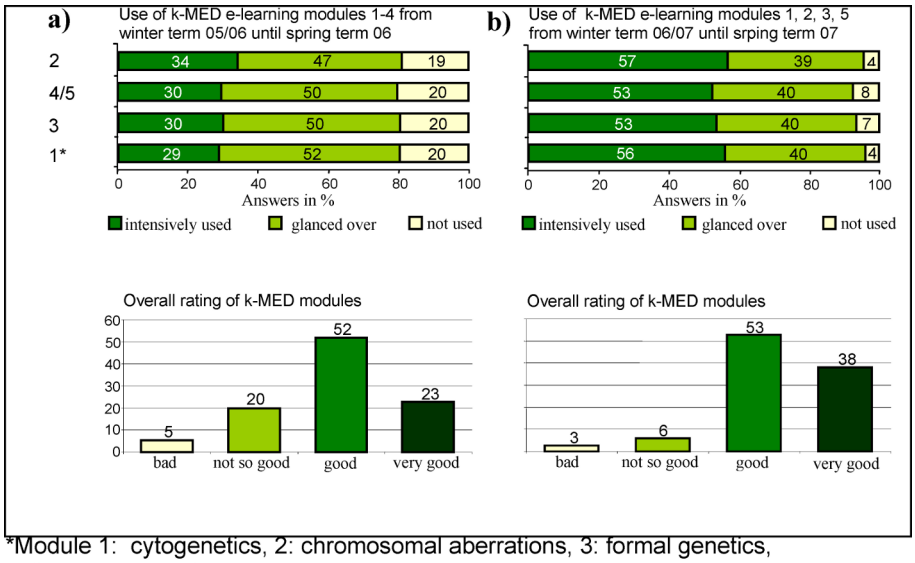
(1) cytogenetics, (2) chromosomal aberrations, (3) formal genetics, (4) fundamentals of molecular diagnostics, (5) congenital abnormalities, * displaces „fundamentals of molecular diagnostics" in the clinical study period since winter term 06/o7

Table 4: Evaluation of the acceptance of the e-learning modules by user-tracking.
Use by medical students in the clinical period and students of human biology.

	(1)	(2)	(3)	(4)	(5)*	target group
accesses	387	573	429		346	students in the clinical period, ST2007 (n~150)
	247	600	446		417	students in the clinical period, ST2009 (n~150)
	25	23	16	20		students of human biology, WT05/06 (n=48)
	33	37	21	27		students of human biology, WT08/09 (n=54)
access per user	3,0	4,1	3,2		2,8	students in the clinical period, ST2007 (n~150)
	2,5	4,6	3,6		3,4	students in the clinical period, ST2009 (n~150)
	2,2	2,4	1,8	2,2		students of human biology, WT05/06 (n=48)
	2,3	2,6	1,7	2,2		students of human biology, WT08/09 (n=54)
times of use (min)	67	166	96		86	students in the clinical period, ST2007 (n~150)
	73	220	157		153	students in the clinical period, ST2009 (n~150)
	48	57	10	25		students of human biology, WT05/06 (n=48)
	79	61	38	19		students of human biology, WT08/09 (n=54)

* replaces „fundamentals of molecular diagnostics" in the clinical study period since winter term 06/07

Table 3 presents the intensity of use of the collective group in winter term 05/06 and the respective cumulative use until summer term 07 and 09. (data source: user-tracking performed by the LMS). Outstanding figures are marked in grey.
Table 4 shows the intensity of use of students in the clinical period in spring term 07 and 09, and of students of human biology in winter term 05/06 and 08/09, respectively
Access is defined as login into a distinct e-learning module (e. g. cytogenetics comprising 29 pages). Due to technical problems – e. g. caused by introduction of the new open source learning platform ILIAS (http://www.ilias.de/docu/) in September 2005 – a distinct evaluation of learning module acceptance and access for each user group (medical students in the preclinical or clinical period, students of human biology) was not possible in all semesters (see Table 3). For that reason the online user tracking data is presented mainly with respect to the collective group in a cumulative way (see Table 4). "Users" are students who attend the respective teaching unit (see Table 2). A time-analysis of user tracking data – to detect possible peaks in the degree of utilisation for example – was compromised by the limited personnel and technical resources.



*Module 1: cytogenetics, 2: chromosomal aberrations, 3: formal genetics, 4: fundamentals of molecular genetics, 5: congenital abnormalities and syndromes. The percentage of students is given in the respective parts of the beams and alternatively above the columns.

Figure 2: Evaluation of k-MED learning modules in the clinical study period. Figure 2a shows the combined evaluation data of winter term 05/06 and spring term 06 (examinees: 454, return questionnaires: 322 = 71 %. Figure 2b gives the respective results of winter term 06/07 and spring term 07 (examinees: 306, return questionnaires: 249 = 81 %). The evaluation of the learning scenario in spring term 09 supplied similar ratings (not so good: 12 %, good: 56 %, very good: 32 %) among 126 examinees and 75 % return questionnaires.

The questionnaire recorded self-estimated times of use and an evaluation of the overall quality of the e-learning modules. To that end we used a four-step scale for answers (bad, not so good, good, very good. The same standardized questionnaire was handed out five tims in winter term 05/06, spring term 06, winter term 06/07, spring term 07, and spring term 09 immediately after the written test covering clinical genetics for medical students in the clinical period (7th and 8th semester). Prior to interpretation the data from the questionnaires was assorted into two groups: Data collected in winter term 05/06 and spring term 06 versus data derived from winter term 06/07 and spring term SS07. The first group holds data having been collected before introduction of the e-module "congenital abnormalities and syndromes", whereas the second group consists of ratings issued after that introduction. This module replaces "fundamentals of molecular diagnostics", because according to user tracking the latter one has been hardly used in the clinical study period (data not shown). Due to limited personal ressources at the center of human genetics a similar evaluation (a more accurate analysis of that substitution of modules) in winter term 07/08, spring term 08, and winter term 08/09 was not possible. An evaluation of acceptance was not carried out with medical students in the preclinical (first) semester and with students of human biology to limit time and effort of this study.

Results

The evaluation and comparison of the times of use proves a stable or even increasing acceptance of the e-learning modules from winter term 05/06 (integration of the online modules into the mainstream curriculum of human genetics) until spring term 2009 (see Table 3 and 4). On an average each of our e-learning modules is accessed twice or more – with the exception of "formal genetics" with students of human biology). Apart from the relative short processing time having been spent on the modules "formal genetics" and "fundamentals of molecular diagnostics" in the human biology group (see Table 4) the average access time reaches over 45 minutes – independently from study class or semester, respectively. In this context we note a strikingly high use of the module "chromosomal aberrations". Obviously, this online teaching unit providing a lot of clinical content satisfies the concerns and learning demands of medical students in the clinical period in a particular way. Table 3 and 4 proove that students in the clinical period use this module most intensively (e. g. 220 minutes average time of use versus 105 minutes cumulative average time of use in the collective group). Students of human biology, who prefer a more scientific focus, display significantly shorter times of use being stable from winter term 05/06 until winter term 08/09 (57 and 61 minutes, respectively). Figure 2 presents a survey of the evaluation during four semesters in the clinical study period. Both of the groups (winter term 05/06 + spring term 06 and winter term 06/07 + spring term 07) differ by the substitution of the module "fundamentals of molecular diagnostics" for "congenital abnormalities". The rating of our e-learning units is strikingly better when compared to the evaluation of winter term 05/6 and spring term 06, respectively. This applies to the use of distinct modules (WT 05/06 - ST 06: 29-34% intensively used; WT 06/07 – ST 07: 53-

57%) and also to the overall rating of our online teaching scenario (WT 05/06 – ST06: 23% very good; WT 06/07 – ST 07: 38% very good). The differences observed in times of use and intensity of use between both groups are significant.

Discussion and Conclusion

Since this evaluation study has been made anonymously, we could not calculate a coefficient of correlation relating times and intensity of use provided by the questionnaire and the data from online user-tracking. However, another study has already proven that information given by students correlate with the "real" parameters from user-tracking [4]. Hence, we conclude that the questionnaire provides reliable results mirroring the learning and study habits of the interviewees. The growing acceptance of our e-modules in human genetics is probably co-determined by the fact that k-MED together with its e-learning modules has been increasingly used in other study groups during the last years. Some kind of blended e-learning scenarios has already become a matter of course at the universities in Giessen and Marburg. When comparing the acceptance of the modules "formal genetics" and "fundamentals of molecular diagnostics" between natural scientists (students of human biology) and medical students, the latter group seems to benefit significantly more than students of human biology. This observation may be explained by the diverse conception of the two study courses. The relative low acceptance of module "fundamentals of molecular diagnostics" with medical students during the clinical study period has most likely two reasons: On the one hand the low level of difficulty of that module is obviously inappropriate for students in advanced semesters (7th and 8th semester), on the other hand it covers topics (e. g. exon-intron organisation of human genes, transcription, translation) that do not arise in the final written exam in clinical genetics. The e-module "congenital abnormalities and syndromes" appears to be particularly adequate for self-directed learning and preparation for the exam, because it holds a great number of exercises (see Table 1).

Finally, we come to the conclusion that our e-learning scenario is broadly accepted among students with different levels of knowledge (natural scientists and medical students in the preclinial and the clinical period, respectively), although it has been implemented for the optional use. We could not confirm a low acceptance rating, which had been observed in single cases of other k-MED online course (e. g. access rates of 10% during one semester) [1]. In this context one has to be aware of the fact that our e-learning modules are recommended by the teaching staff within a blended learning scenario at the beginning of each semester. The advantages of self-directed learning, which is (mostly) time- and location-independent, obviously outweigh the additional amount of work reflecting the results from other studies [1], [5]. The participating teachers benefit as well, because work burden is relieved in the online and the classical teaching courses through new communication forums. Minor adaptations such as the exchange of the barely accessed e-module "fundamentals of molecular diagnostics" for "congenital abnormalities and syndromes" in the clinical study period could heighten acceptance and usage even more (see Figure 2). To our knowledge there is – at least in the German speaking countries - no similar project for teaching the basics in human genetics. Since we know from experience that online tests are highly accepted by teachers and learners at the faculty of medicine in Marburg [6], we recommend the implementation of online options for testing also in human genetics. Gresty and coworkers [7] could show that there is an awareness of the growing importance of human genetics and at the same time a high acceptance of online teaching courses among employees in the health care system. Therefore, our online genetics resource seems suitable for instruction and education of assistant medical technicians and nurses, as well. Surely, this statement has to be verified by evalutation studies similiar to this work.

At the faculty of medicin in Marburg e-learning modules have already been evaluated with regard to the students' success rates in exams and practical courses [8]. In the framework of a successor project such a study appears as an important supplement of the present evaluation of use and acceptance.

Notes

Parts of this work have been presented on the 19th meeting of the German society of human genetics (GfH) at Hannover [9].

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Competing interests

The authors declare that they have no competing interests.

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