E-learning approaches in biometry and epidemiology

E-Learning-Kurse in Biometrie und Epidemiologie

Abstract

Education is an integral component of increasing our profession's profile. While master and PhD level education in biostatistics and epidemiology is provided at high levels in several regions, there are parts of the world deserving proper specialized education. E-learning may be one option because traveling costs can be avoided, and the capacity of teachers can be multiplied by making appropriate use of e-learning tools. The aim of this work was to explore the availability of e-learning approaches in the areas of statistics, biometry, biostatistics, epidemiology, and genetic epidemiology by a systematic literature search and a search in databases. We identified a total of 25 courses. They differ with respect to target audience, content, amount and quality. Many of them had been developed at a time when technical aspects were the main hurdle at the stage of course development. Important hygiene and motivation factors were generally unknown at that time, and, subsequently, ignored. As a result, none of the courses provides exercises that generate individual feedback to motivate the student, and no varying degree of complexity is observed. Many courses do not fulfill modern needs for e-learning. In conclusion, the development of modern e-learning following recent didactical concepts is urgently required. Sustainability of these courses is crucial and can be best guaranteed by using available technological platforms. These allow the use of common didactical principles, robust and reliable technology.

Keywords: blended learning, distance learning, e-learning, self-learning

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Zusammenfassung

Ausbildung ist ein integraler Bestandteil unserer Profession. Während Master- und Promotionsmöglichkeiten in Biostatistik und Epidemiologie in verschiedenen Ländern auf hohem Niveau angeboten werden, gibt es andere Regionen, die eine adäquate spezifische Ausbildung erfordern. E-Lernen könnte eine Alternative zur Präsenzlehre sein, da Reisekosten vermieden werden und die Verfügbarkeit eines Dozenten durch die Verwendung geeigneter e-Lernen-Programme unbegrenzt erhöht werden könnte. In einer systematischen Literaturrecherche und einer Suche in Datenbanken wird die Verfügbarkeit von Angeboten aus den Bereichen e-Lernen in den Gebieten Statistik, Biometrie, Biostatistik, Epidemiologie und Genetische Epidemiologie untersucht. Insgesamt haben wir 25 Kurse identifiziert. Diese unterscheiden sich erheblich im Hinblick auf Zielgruppe, Inhalt, Umfang und Qualität. Die meisten Kurse wurden zu einer Zeit entwickelt, als die technischen Aspekte die größte Herausforderung bei der Entwicklung eines Angebots waren. Wichtige Hygiene- und Motivationsfaktoren waren zu diesem Zeitpunkt unbekannt und wurden daher nicht berücksichtigt. In Konsequenz wird den Studierenden in keinem der Kurse eine individuelle Rückmeldung gegeben. Es werden keine unterschiedlichen Schwierigkeitsgrade in Abhängigkeit des Kenntnisstands abgebildet. Viele Kurse erfüllen daher nicht die Anforderungen, die heutzutage an e-Lernen gestellt werden. Die Entwicklung moderner e-Lernen Angebote, die relevante didaktische Konzepte integrieren ist zwingend erforderlich. Die Nachhaltigkeit dieser Kurse ist wichtig und kann am besten durch die Verwendung von

Plattformen gelöst werden, die spezifisch für diesen Zweck entwickelt wurden. Diese erlauben den Einsatz allgemein anerkannter didaktischer Prinzpien, sowie robuster und zuverlässiger Programme.

Schlüsselwörter: computergestütztes Lernen, e-Didaktik, e-Lernen, Fernunterricht, Kombilernen, Online-Lernen, Selbst-Lernen

Introduction

Education is an integral component of increasing our profession's profile. While master and PhD level education in the interdisciplinary subjects biometry, biostatistics, epidemiology and genetic epidemiology is provided at high levels in several regions, there are parts of the world where biostatisticians and epidemiologists have to fight hard to have their discipline recognized as one deserving proper specialized education [1].

Further enhancement of the biometric, biostatistical, epidemiological and genetic epidemiological professions will be most efficient if both the profession itself as well as its many scientific partners receive appropriate initial, graduate and continuing training. A part of this training can take place in satellite meetings and educational sessions at conferences, short courses or summer schools. These activities are, however, expensive because they require traveling of teachers and/or students, and they are fixated on a specific time point or period. The traveling costs can be avoided and the capacity of teachers can be multiplied by making appropriate use of e-learning tools.

Different definitions have been given for the term e-learning. For example, some authors require that e-learning only means web-based systems ([2], p. 28), while others mean computer-based teaching and learning. The latter is a combination of a phase of attendance, i.e., classical ex-cathedra teaching plus autonomous teaching by use of a teaching software [3]. This combined form of teaching usually is termed blended learning [4] and combines the advantages of both teaching forms. In this report, we allow for both definitions, i.e., self-learning e-learning courses as well as blended learning approaches that combined an online phase with a phase of attendance.

The quality of the available e-learning depends on the extent to which they meet important hygiene and motivation factors (for details and definitions, see next section). Some of the most important hygiene factors concerning e-learning include the unlimited technical operational capability of the learning object, a consistent, integrative and intuitive navigation, a precise and clearly arranged structure of contents and pages, consistency of topics as well as the adequate consideration of the heterogeneity of the target audience [5]. The most important motivation factors are a high grade of interactivity as well as demanding and at the same time motivating learning items [5]. These criteria are not fulfilled for webinars and video tapes of seminar talks and lectures, and we therefore explicitly exclude these courses from further consideration. However, we absolutely agree with colleagues (see,

e.g. [6]) that this form of distance learning can be very helpful, especially for special topics which are usually taught in continuing education.

Because we excluded this important strand of distance learning from this survey, we refer to http://www.pitt.edu/~super1/ for a collection of more than 2000 epidemiology presentations and to the world wide web virtual libraries for statistics and epidemiology.

The aim of this paper is to explore the availability of e-learning approaches in the areas of statistics, biometry, biostatistics, epidemiology, and genetic epidemiology by a systematic literature search and a search in databases. To this end, we conducted a systematic literature search, a systematic search in the databases Web of Science (WoS), Google Scholar (GS) and in the world wide web virtual library of statistics. First, we examined e-learning courses which focus on learning topics in the field statistics, biostatistics and biometry. We specifically included statistics because the contents of courses in biostatistics and genetic epidemiology are strongly influenced by statistics (see, e.g. [7], [8], [9]). Furthermore, the term biometry is primarily used in the area of pattern recognition, thus sometimes not related to biometry as defined by the German Society of Medical Informatics, Biometry and Epidemiology and the International Biometric Society. We also investigated the areas of epidemiology and genetic epidemiology. After a brief description of the search strategy we discuss the identified courses in detail. For each e-learning course we firstly give a short description of the product, and, if necessary, of the project behind as well as the target group. This is followed by a short but critical discussion on the didactical aspects regarding the e-learning material.

We expect to identify many courses that have been developed at a time, i.e., three to ten years ago, when technical aspects of the course were the main hurdle at the stage of course development. It is important to note that the importance of hygiene and motivation factors was generally unknown in the context of e-learning at this time. Furthermore, the technical prerequisites for implementing these important factors were not available at this time. Therefore, we expect that many courses do not fulfill modern needs for e-learning. And the deviation from these high demands is expected to be higher for older courses.

Methods

Motivation and hygiene

In the late 1950's, Herzberg derived the two factor motivation hygiene theory for satisfaction at a workplace [10]. Identifying satisfiers and dissatisfiers led Herzberg to determine motivation and hygiene factors that employers could apply to improve employee satisfaction in the workplace. The motivation factors are those that increase satisfaction if they are present but generally do not lead to dissatisfaction if they are absent. Hygiene factors however cannot motivate but cause dissatisfaction if they are absent.

Today, Herzberg's motivation and hygiene principle finds an interesting application in eLearning practice. Exchanging employment for education and employees for students, the following motivation and hygiene factors are proposed [11]:

Motivation factors:

- enthusiasm and commitment of educators
- feedback and academic mentoring from tutors
- serendipity
- a sense of community

Hygiene factors:

- clear expectations
- prompt assignment return
- reliable learning management system technology
- flexibility and control
- institutional policies and procedures

If the proposed motivation and hygiene factors are accurate, the following generalizations can be made about e-learning [11]:

- The online tutor and his or her activity is key to satisfaction in e-learning.
- The establishment of online community is a vital element of e-learning.
- The actual technology used in e-learning cannot satisfy. However, a poor choice can cause dissatisfaction.
- Providing students with flexible learning opportunities does not motivate them. However, its absence would cause dissatisfaction.

Exclusion criteria

An e-learning course can only be used at any institution if it is without commercial interest. Furthermore, it needs to transfer theoretical knowledge in addition to content that is relevant in applications. E-learning tools not fulfilling this important criterion or which are only available through a high license fee were excluded from this investigation. This exclusion criterion was fulfilled, e.g., when the audience consisted in companies of when the e-learning tool was designed for teaching a specific statistical software package.

Furthermore, we restricted this study to projects available in English and/or German. A reviewer has noted that a restriction to English courses would be reasonable. However, prior to our literature search we were aware of the funding initiative for e-learning courses by the German Ministry of Education and Research which led to the development of several courses of questionable quality. Because some of these courses can serve as examples how e-learning courses should not be constructed, we decided to include the German language in our literature search.

Literature search in the Web of Science

Aim was a systematic literature search for identifying e-learning courses in statistics for use without phase of attendance, and e-learning courses in these areas based on a teaching and learning concept that includes a phase of attendance. The systematic literature search was conducted on July 8, 2009 in the ISI Web of Knowledge, Web of Science (WoS): http://apps.isiknowledge.com/ without restrictions with respect to the time period. The databases searched were SCI-EXPANDED, SSCI and A&HCI, CPCI-S, and CPCI-SSH. The topics searched are given column 1 of Table 1.

Literature search in the World Wide Web Virtual Library: Statistics

The search was conducted on July 8, 2009 in the category "on-line educational resources" at http://www.stat.ufl.edu/vlib/statistics.html.

Literature search in the World Wide Web Virtual Library: Medicine and Health: Epidemiology

The search was conducted on July 11, 2009 in the category "on-line educational resources" at http://www.epibiostat.ucsf.edu/epidem/epidem.html.

Literature search in Google Scholar

The search was conducted on July 13, 2009 in the Scholar advanced search mode on http://scholar.google.de/. The period was restricted to 2000–2009, and the search terms are given in column 1 of Table 2.

Literature search on egms.de

Finally, we performed a search for e-learning topics on http://www.egms.de/ using the terms 'biometrie e-learning' and 'epidemiologie e-learning'. The use of the English terms gave the same findings.

Table 1: Hits identified in the search of the Web of Science on July 8, 2009

Topic	Hits	Relevant hits
(statistic* AND e-learning)	119	8♣
(biostat* AND e-learning)	0	0
(biomet* AND e-learning)	8	0♣
(epidemiol* AND e-learning)	9	1♣,♠
(statistic* AND "distance learning")	101	2
(biostat* AND "distance learning")	4	0
(biomet* AND "distance learning")	3	0
(epidemiol* AND "distance learning")	19	3♥
(statistic* AND "blended learning")	9	0
(biostat* AND "blended learning")	0	0
(biomet* AND "blended learning")	0	0
(epidemiol* AND "blended learning")	0	0
Total without duplicates	262	18

♣ One additional e-learning course for evidence-based medicine identified

♠ Course from [21] not available to the public. According to the additional information kindly provided by the authors, the current course was developed according to the standard principles of e-learning of [2, 14].

♥ Course from Ref. [14] not available; the course Epidemiology for Advanced Nursing Practice (NU.625) of [28] is still in use but available to local students only.

Table 2: Hits identified in the search of Google Scholar on July 13, 2009. Years were restricted to 2000–2009.

Topic	Hits	Relevant hits
statistik biometrie e-learning	40	3
statistics biometry e-learning	269	1
+biometry +e-learning	107	2
statistics biometrics e-learning	206	1
statistik epidemiologie e-learning	39	2
+statistics +epidemiology +"e-learning"	551	0*
statistics +biometry +"distance learning"	32	1
statistics +biometrics +"distance learning"	147	2
statistics +epidemiology +"distance learning"	761	2*

* In first 100 hits.

Results

Search hits

Web of Science

The search in the WoS for 'statistic* AND e-learning' and for 'statistic* AND "distance learning"' revealed by far the most hits (Table 1). In total, 119 and 101 articles, respectively, were identified using these terms. Many false positive hits were related to the statistical analysis of the underlying technologies, the didactical methods or the comparison of a specific course with another one. Other hits included e-learning topics but were unrelated or only marginally related to statistics. Most hits for the term 'Biomet' were related to the web authentication of students. The WoS search gave no hits for four searches, and combinations with the term 'blended learning' were the least frequent found. In total, 262 different references were found, and 16 references describing online courses for statistics, biostatistics, and epidemiology were identified. Two of the courses were related to specific software [12], [13], and two courses are not available anymore [14], [15]. Two references refer to one specific course which was not investigated in detail because the e-

learning module is on business statistics [16], [17]. Furthermore, it is unavailable to the public; thus, we excluded it from further considerations. One reference described a retro-looking computer game to explain the normal distribution [18], and it thus is not a complete online course. It was therefore excluded from further considerations. Another paper describes the architecture for distance learning to support statistics training by a tutor system [19]. It is therefore not a complete course, and thus not considered further. The Dynamic Virtual Learning Networks [20], available at http://umberto.policlinico.unina.it/, are available in Italian, and were therefore excluded from further consideration.

The material of Viehmann and Jöckel [21] has been presented at a conference and is available as an abstract only. The course material is not accessible to the public, and it contains additional material to the lectures and exercises. It is not a complete course and therefore excluded from further considerations.

Lee and Lee [22] described the *e-StatEdu* System which was not found on the web. However, a short description of the course can be provided because of the detailed information given in [22]. Larreamendy-Joerns et al. [23] summarized 6 online statistics courses, and they will be described below in greater detail. Krause et al. [24] describe the e-learning environment on correlation analysis *Koralle*. Through Härdle et al. [25], [26], we identified the course *MM*Stat*, *EMILeA-stat*, which is the acronym for *E*ine *m*ultimediale, *i*nternetbasierte und interaktive *Lehr*- und *Lern*umgebung in der *a*ngewandten *Stat*istik, the examination preparation system Q&A, the abbreviation for questions and answers (http://mars.wiwi.hu-berlin.de/qa/), *DoLStat@d*, the data oriented learning system of statistics, and several e-books on statistics. Q&A [27] does not provide a complete course, and it is therefore not considered further. Similarly, the e-books are excluded from further review. Finally, the authors of [28] kindly provided the information that their course, entitled Epidemiology for Advanced Nursing Practice (NU.625), is in use. However, the material cannot be accessed from outside of the Thomas Jefferson University, and the course therefore had to be excluded from further considerations.

World Wide Web Virtual Library: Statistics

The search in the World Wide Web Virtual Library: Statistics revealed seven hits which are displayed in Table 3. All but the last hit listed are material, e.g., text, figures or animations, on a very specific topic in statistics that can be used for teaching purposes and exercises. None of the available material is a complete e-learning course or complete e-learning module. The last hit listed is *HyperStat* (http://www.davidmlane.com/hyperstat/, see Figure 1). It is an internet platform with considerable information and links on statistics. Integrative part of the page are the introductory text book [29] and the online tutorial.

In 2005, Larreamendy-Jones et al. [23] described and reviewed six online statistics courses, and all but one are

still available (Table 4). Some of the described courses are freely available or for a small fee, while others have a high tuition fee. For example, the Psychology 3000 Online course is available for 770 US $ (July 11, 2009).

World Wide Web Virtual Library: Medicine and Health: Epidemiology

This search revealed no hits.

Google Scholar

The first hit for the search term 'statistik biometrie "e learning"' was Kladobra [30], who compared the courses *Statistik: Beschreibende Statistik und explorative Datenanalyse* (Descriptive Statistics and Exploratory Data Analysis), *Neue Statistik II* (New Statistics), *PC-Statistik-Trainer* 1.0 (PC Statistics Trainer), *LernSTATS*, and *EMILeA-stat*. The second hit referred to *JUMBO*. No other courses were identified with this search term.

One further course [31] was identified with the search terms 'statistics biometry e-learning'. It describes the comparison of an introductory course to biostatistics held in the traditional form and as distance learning. The material for the distance learning course was, however, standard material, including video lectures and powerpoint presentation slides. The potential of e-learning tools was used by no means. Therefore, the course is excluded from further consideration.

Literature search on egms.de

Eight and 7 hits were observed for the search using the terms 'biometrie e-learning' and 'epidemiologie e-learning', respectively, and this search revealed one important additional reference [32] on both search terms. Muche [32] compared the courses *EMILeA-stat*, *Neue Statistik* (New Statistics), *ActivStats*, *AST* (Adaptive Statistics Tutor), *Grundbegriffe der Biostatistik* (Basic Terms of Biostatistics), *Rice Virtual Lab in Statistics*, *JUMBO* – standing for the *Java-u*nterstützte *M*ünsteraner *B*iometrie-Oberfläche (Java supported biometry interface from Münster) –, *LernSTATS* which meanwhile has been modernized and integrated in the Methodology toolbox, the multimedia learning software of the FernUniversität in Hagen, *Visual Bayes*, *VisualStat*, *ROBISYS* – *Ro*stocker *Bio*metriesystem –, *NUMAS* – *Nu*merical *M*athematics *A*nd Statistics. The Rice Virtual Lab in Statistics hosts the *HyperStat* course which has been identified in the WoS search.

Table 3: Hits identified in the search of the World Wide Web Virtual Library: Statistics on July 11, 2009

Name	Web address
Probability distributions and their properties	http://www.geocities.com/~mikemclaughlin/math_stat/Dists/Compendium.html
Central limit theorem	http://www.statisticalengineering.com/central_limit_theorem.htm
General tutorial on (univariate) mathematical modeling (pdf)	http://www.geocities.com/~Emikemclaughlin/op_cit/Tutorial.pdf
Java applets for visualization of statistical concepts	http://lstat.kuleuven.be/java/index.htm
Java application simulating the central limit theorem	http://www.rand.org/statistics/applets/clt.html
Statistical Java – Virginia Polytechnic Institute*	http://www.causeweb.org/repository/statjava/
HyperStat	http://davidmlane.com/hyperstat/

* Link via World Wide Web Virtual Library: Statistics not operating; material has moved to link provided in 2nd column

Figure 1: Screenshot of the graphical user interface of HyperStat

Table 4: Courses identified from [23] and their current web addresses (accessed on July 11, 2009)

Name	Web address
CyberStats	http://media.duxbury.com/duxbury/cyberstats/cyberstats_demo.html *
StatCenter Psych 3000 Online	http://www.psych.utah.edu/stat/
Introductory Statistics: Concepts, models, and applications	http://www.psychstat.missouristate.edu/introbook/sbk00.htm
Investigating Statistics	Unavailable
Seeing Statistics	http://www.seeingstatistics.com
SurfStat	http://surfstat.anu.edu.au/surfstat-home/surfstat-main.html

* Demo

Summary of search results

In total, we identified 25 different e-learning courses for statistics in the field medicine, biostatistics, biometry and epidemiology:

1. *ActivStats* (http://www.pearsonhighered.com/activstats/)
2. *AST* (Adaptive Statistics Tutor); not available anymore
3. *CyberStats* (http://media.duxbury.com/duxbury/cyberstats/cyberstats_demo.html), see Table 4
4. *DoLStat@d* (http://mo161.soci.ous.ac.jp/@d/DoLStat/)
5. *EMILeA-stat* (http://emilea-stat.rwth-aachen.de/, http://www.emilea.de/)
6. *Grundbegriffe der Biostatistik* (Basic Terms of Biostatistics)
7. *HyperStat / Rice Virtual Lab in Statistics* (http://www.davidmlane.com/hyperstat/, http://www.onlinestatbook.com/rvls.html)
8. *Introductory Statistics: Concepts, models, and applications* (http://www.psychstat.missouristate.edu/introbook/sbk00.htm), see Table 4
9. *Investigating Statistics* (unavailable), see Table 4
10. *JUMBO* (http://www.campus.uni-muenster.de/fileadmin/einrichtung/imib/lehre/skripte/biomathe/jumbo.html)
11. *Koralle* (http://www.uni-saarland.de/fak5/stark/)
12. *LernSTATS*; old, integrated into Methodenlehre-Baukasten
13. *Methodenlehre-Baukasten*, Fachrichtung Medizin (Methodology toolbox, field medicine) (http://www.methodenlehre-baukasten.de/web/php/kurs.php?fach=medizin)
14. *MM*Stat / Statistik – Wissenschaftliche Datenanalyse leicht gemacht* (Statistics – Scientific Data Analysis Made Simple)
15. Multimedia-Projekt "Neue Statistik" (http://www.fernuni-hagen.de/stat/)
16. *Neue Statistik II* (New Statistics) (http://www.neuestatistik.de/)
17. *NUMAS* (http://www.numas.de/)
18. *PC-Statistik-Trainer* 1.0 (PC Statistics Trainer)
19. *ROBISYS* (http://www.imib.med.uni-rostock.de/IMIB/HTML/elearning/elearning_start.php)
20. *Seeing Statistics* (http://www. seeingstatistics.com/), see Table 4
21. *Statistik: Beschreibende Statistik und explorative Datenanalyse* (Descriptive Statistics and Exploratory Data Analysis); offline available via CD
22. *StatCenter Psych 3000 Online* (http://www.psych.utah.edu/stat/), see Table 4
23. *SurfStat* (http://surfstat.anu.edu.au/surfstat-home/surfstat-main.html), see Table 4
24. *Visual Bayes* (http://www.imbi.uni-freiburg.de/medinf/projekte/vbayes_e.htm)
25. *VisualStat* (http://www.visualstat.com/)

All courses but those identified from the review paper [23] (see Table 4) are now discussed with respect to motivation and hygiene factors in alphabetical order.

Specific courses

1. ActivStats

ActivStats is an e-learning software for PC and MAC available as student version in bookstores [33]. ActivStats is available since 1999, and version 7 was released early in 2008. It covers the topics descriptive statistics, random experiments, testing hypotheses, regression, and analysis of variance. A voluminous ActivStats Teachers Guide is offered in addition to the software, which enables the lecturer to apply the product in a didactically reasonable way (online available via http://www.datadesk.com/support/guide/).

Discussion

At the latest by examining the wrapping, it becomes obvious that ActivStats is dedicated to users of specific software products; on the front page you find "Learn how to use Data Desk, JMP, Excel, MINITAB and SPSS". A noticeably more expensive version of ActivStats is available at the manufacturer of Data Desk in addition to the student version. With this, it is said: "ActivStats is an innovative multimedia education product that teaches introductory

college-level statistics and the use of our Data Desk data exploration package" (http://www.datadesk.com/ products/mediadx/activstats/). The intention therefore seems to be to learn the handling of the software Data Desk. Therefore, we do not examine this e-learning course further.

2. AST (Adaptive Statistics Tutor)

The website is unavailable, and an extended web search did not reveal any search results.

3. CyberStats

CyberStats (Table 4) is described in [23], and therefore not described here.

4. DoLStat@d

DoLStat@d – *Data oriented Learning System of Statistics* was developed from 2002 to 2006, and it was published as html-based online course. Only 9 of the planned 21 chapters have been realized. The learning system is not maintained for some time, and the links to the few realized chapters are not working. Therefore, we refrain from describing this course in detail.

5. EMILeA-stat

EMILeA-stat is an internet based teaching and learning environment for applied statistics [34]. EMILeA-stat emerged of the project e-stat, which was funded by the German Ministry of Education and Research from 2001 to 2004 within the program New Media in Education from April 2001 to December 2004 with a total budget of 2.9 Mio. Euro. Thirteen principal investigators and 70 researchers took part in this project. The teaching system is available online through the project page (http://www.emilea.de/, Figure 2). On the start page, the user can choose between different alternatives to get access to the learning contents and items. For example, it is possible to get direct access to learning units for specific topics (Figure 3), or the user can select courses where contents and learning units are arranged according to functional aspects. The following learning units are available in EMILeA-stat: official statistics, association, descriptive statistics, entropy, exploratory data analysis, finance mathematics, linear structural equations, machine learning, basic calculus, critical review of PISA 2000, numerical methods, quality optimization, robust statistics, inferential statistics, sequential methods, statistics of finance markets, stochastics in school, stochastic processes, generalized linear models, actuarial mathematics, probability calculus, econometrics and demography, and time series analysis.

Discussion

EMILeA-stat is a voluminous collection of learning material for statistics. Even though the content was provided by several different authors, the presentation of the content and learning units is homogeneous and very consistent. The database using Content Management System is created in an attractive and modern way. It consistently follows the didactical concept which is described on the project web site and in [34].

Running over the pages, we noticed that the construction has the character of an electronic textbook. For example, no directly integrated interactions to illustrate complex contents were used. Beside some exceptions, no learning units or exercises are available, and only a few problems and solutions are available. A direct online solution is not possible. As a result, the student does not receive any feedback by the teaching system. The didactical additional benefit compared to a textbook can be found in the clear structure, in the linking of content, and in the simple navigation across topics. The actual content mainly consists in text, formulae, and tables. In addition, some figures and very few Java Applets are available for some topics. However, the latter are not directly linked to the content but have to be accessed by a sub-menu.

Härdle et al. [26] criticized the project as follows: "The e-stat project mainly suffered from technical and content issues. The complicated structure of modules requires a certain amount of knowledge, especially of XML. Furthermore the different modules are diverse, in their quality and amount. For some modules there are extensive descriptions at all levels, for a large proportion of modules there are only information at one of three levels."

6. Grundbegriffe der Biostatistik (Basic Terms of Biostatistics)

Grundbegriffe der Biostatistik (Basic Terms of Biostatistics) is an interactive pdf document (http://www.biostat.uzh.ch/teaching/lecturenotes/online/olscriptku.pdf) which is meant to support the students of Zürich University in learning the basics of biostatistics. The learning environment can be compared with an electronic textbook which is equipped with basical navigation buttons on the right (forward, back, jump to, etc.). The document provides several exercises with yes/no answers. The learner can check his/her solutions for each item by mouse clicks. The content covers descriptive statistics, probability, testing hypotheses and regression.

Discussion

Several animations and interactions (Java applets) are linked to the content. It was the intention of the author that they pop up in a separate window of the web browser after mouse click on the respective hyperlink. The most recent version of the course was released in 2004 and was not adapted to the rearrangement of the content management system of the university. As a result, the links to the animations do not work anymore. They can only be used with direct links from the "funpark with statistical simulations", a loose collection of animations
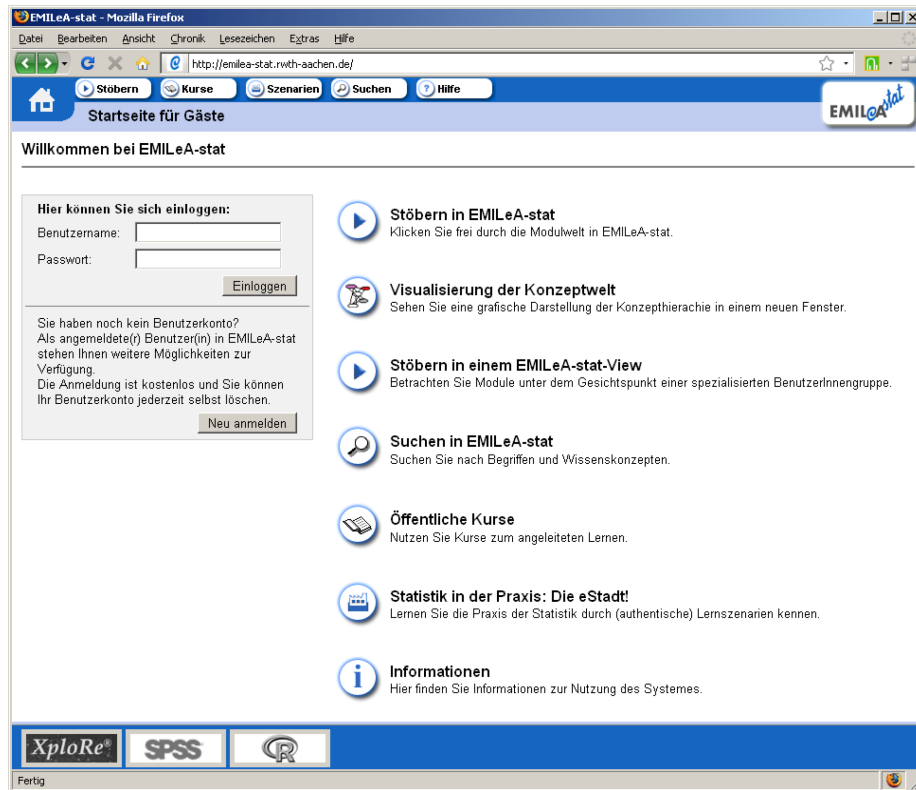
Figure 2: Screenshot of welcome page of EMILeA-stat. The page is appealingly designed and well arranged. The user can choose whether he/she wants to rummage in the different learning modules (Fig. 3) or start an available course. The course on descriptive statistics (measures of location and dispersion) is freely accessible.
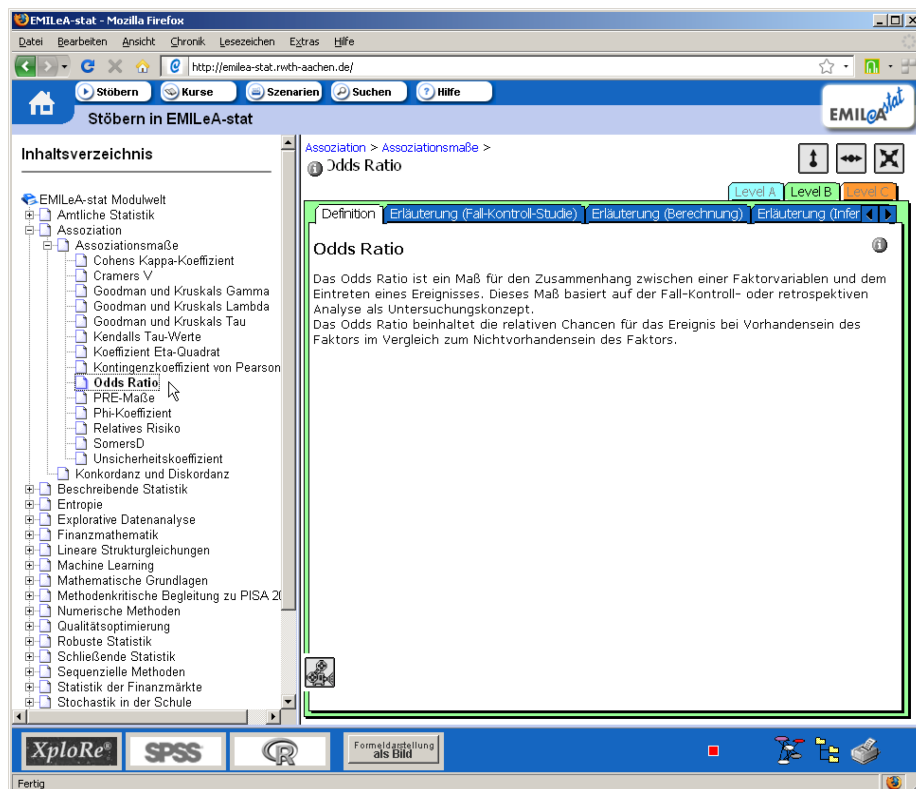

Figure 3: Screenshot of the learning environment of EMILeA-stat. The navigation tree is on the left-hand side, and the user can browse through the different modules. In this example, the module association has been started, and the chosen topic is measures of association, odds ratio. The learning content is shown on the right. The content is mostly restricted to pure text, formulae and tables.

(http://www.biostat.uzh.ch/teaching/lecturenotes/online.html). The yes/no exercises are of a low complexity level and can contribute only in part to the learning success. No feedback is provided to the learner in addition to the number of correct answers.

7. HyperStat / Rice Virtual Lab in Statistics

"HyperStat Online Statistics Textbook" (Figure 1) is an English internet platform, containing a wide range of information and links referring to statistics. The central component of this site is the introductive statistic textbook and online-tutorial by Prof. David Lane, Rice University, Houston (TX), USA (http://www.davidmlane.com/hyperstat/). The following contents are linked on the web site: univariate and bivariate data, probability, distributions, point estimator, confidence intervals, testing hypothesis, power, analysis of variance, regression, distribution-free tests, and measuring effect sizes. HyperStat is also available via the "Rice Virtual Lab in Statistics" web site (http://www.onlinestatbook.com/rvls.html), where further teaching material for statistics can be found.

Discussion

In essence, HyperStat can be used as an e-learning course although it has the character of a textbook. Thus, it is a collection of content, and not an integrated e-learning course with a clear didactical e-learning concept. The web page HyperStat is online since 1993, and by viewing the pages it becomes clear that no adaptations to new ergonomic and design standards have been implemented since. For example, many pages include a "next" button, which is replaced by a "prev" button at the end of a chapter. Thus, it is impossible to navigate from chapter to chapter. The learner has to change to the table of contents each time instead. The content is predominantly made up of text with only a few illustrations. Exercises are not available. In summary, many of the motivation and hygiene factors discussed above are not taken into account. The didactical additional benefit compared to a pure textbook can be found only in the quicker navigation through the contents and in the quicker tracing of cross references by hyperlinks.

8. Introductory Statistics: Concepts, models, and applications

This course is described in detail in [23], and therefore not discussed here.

9. Investigating Statistics

This course is described in detail in [23], but is not available anymore. It is therefore not discussed here.

10. JUMBO

The "Java-unterstützte Münsteraner Biometrie-Oberfläche" (JUMBO), Java supported Münster biometry interface, is an html-based learning environment for the basics of biometry (Figure 4). The learning environment can be used online, but it is also available as CD from the authors. The use of JUMBO is free of charge. This e-learning course covers descriptive statistics, probability calculus, random variable, testing hypotheses, distributions, and design of experiments. A precursor of JUMBO was first presented in 1997, and the complete course was published in 2001 [35]. The most recent version of JUMBO (Version 6.8) dates of 2002.

Discussion

The development of JUMBO's user interface started more than a decade ago, and it has never been adapted to newer standards. For example, the screaming colors which were frequently used for private web sites in the 90's are catching the eye at once. On every page, there are blinking buttons and cliparts in the gif file format which are known to appear distracting for many users and deflect from the content (Figure 5). They can even be demotivating (http://www.heise.de/kiosk/archiv/ct/2000/05/246). Each chapter was placed on a single HTML page. As a result, the chapter on descriptive statistics I requires 22 screen pages at a resolution of 1280 × 1024 and has to be scrolled with the mouse or the keyboard very often for reading. A very pleasant feature of the course is the large number of interactions (Java applets). However, they open in a new window each time. At the end of each chapter, a Java applet with multiple choice problems is available. Unfortunately, we were not able to start these problems neither with the Firefox Browser nor with the Internet Explorer in testing.

11. Koralle

The computer-based learning environment for correlation analysis is an html-based online course developed in 2002. It is not a complete course because it only covers correlation analysis. It is therefore not considered here.

12. LernSTATS; old, integrated into Methodenlehre-Baukasten

LernSTATS is an html-based learning environment, and the target audience is psychology students. With a total of 11 chapters, the following topics are covered: scales, frequency distributions, measures of location and of variability, standardization, correlation, regression, and factor analysis. Small interactions (Adobe Flash Format) are integrated periodically within the learning pages to illustrate the theoretical knowledge (Figure 6).
LernSTATS was developed as an innovation project at Hamburg University. It has been integrated into the Methodenlehre-Baukasten (MLBK), and this further de-
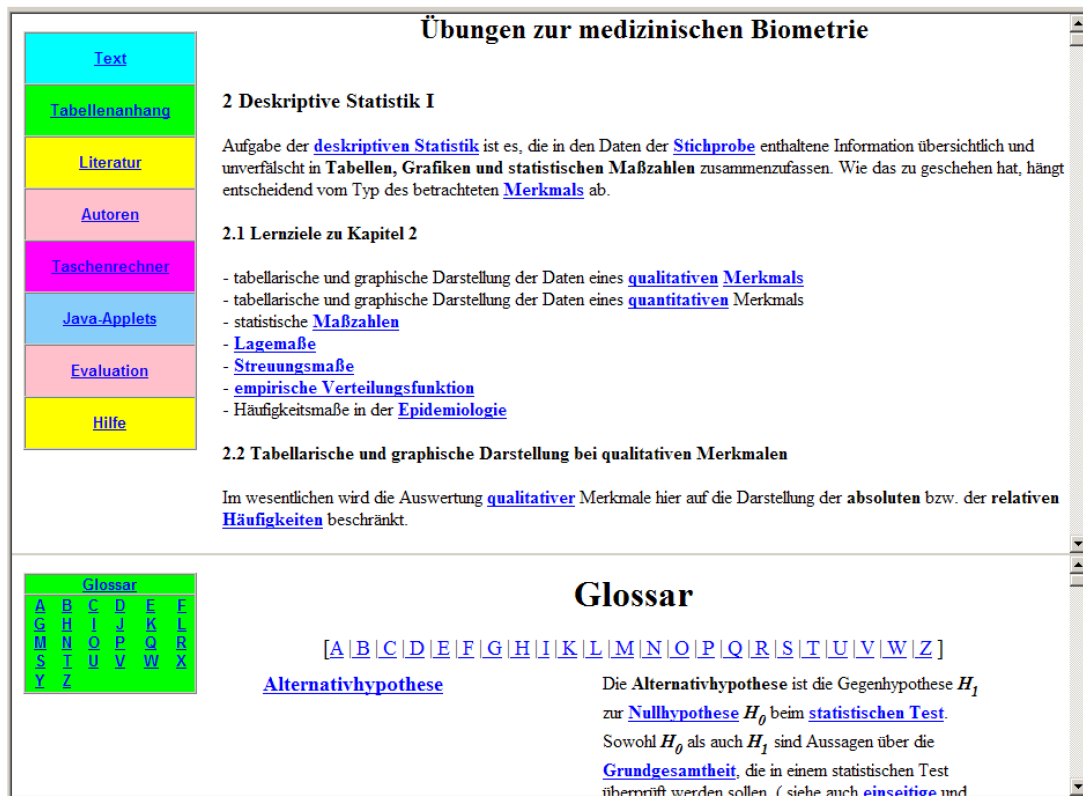
Figure 4: Screenshot of the graphical user interface of JUMBO which has been designed using frames. At the lower bottom of the screen, the glossary is shown permanently. The flashy colors of the navigation bar remind of web pages from the early times of the internet and do not conform with modern ergonomy standards [43].
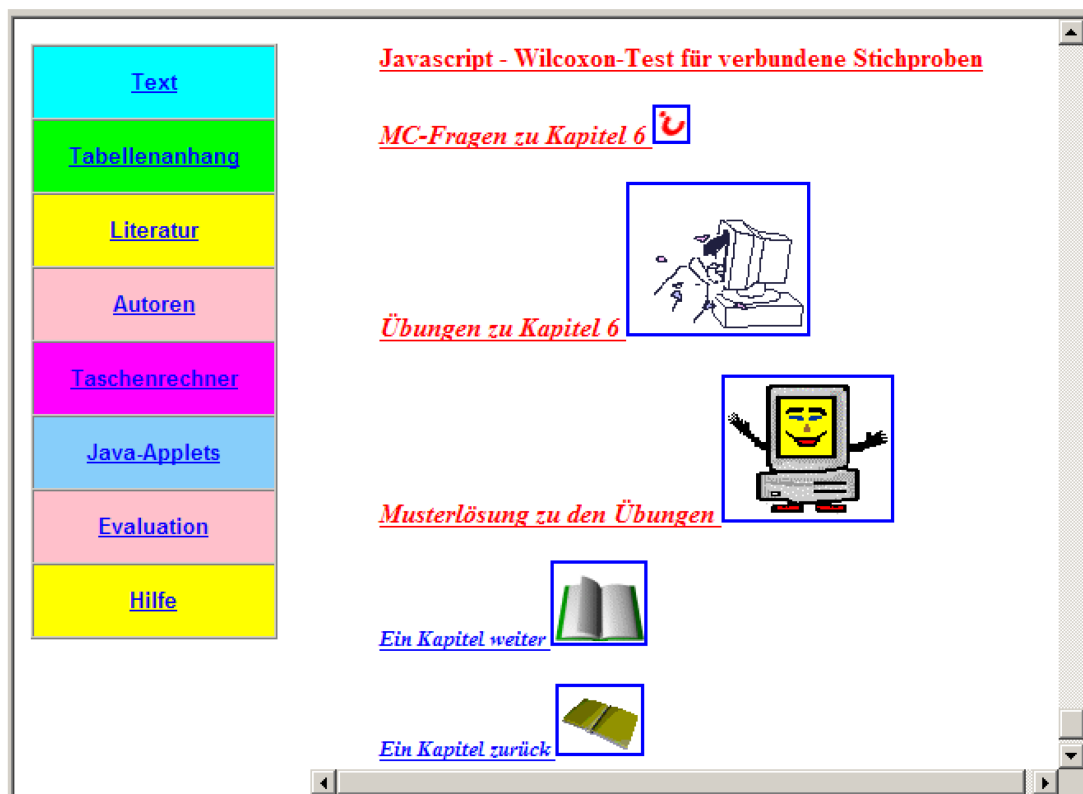

Figure 5: Screenshot of a content page of JUMBO. Flashing buttons and cliparts in gif file format appear distracting for many users and deflect from the content.

Figure 6: Screenshot of the graphical user interface of LernSTATS

velopment was funded by the German Ministry of Education and Research within the program "New Media in Education".

Discussion

In the literature, it is said about LernSTATS that "it is a little doubtable if the program really is appropriate for autonomous learning of the basics of statistics … [since] the very lean theoretical explanations … mostly do not exceed the niveau of a fomulary" ([30], p. 337). Because it has been integrated into MLBK, an in-depth discussion of LernSTATS is not required.

13. Methodenlehre-Baukasten, Fachrichtung Medizin
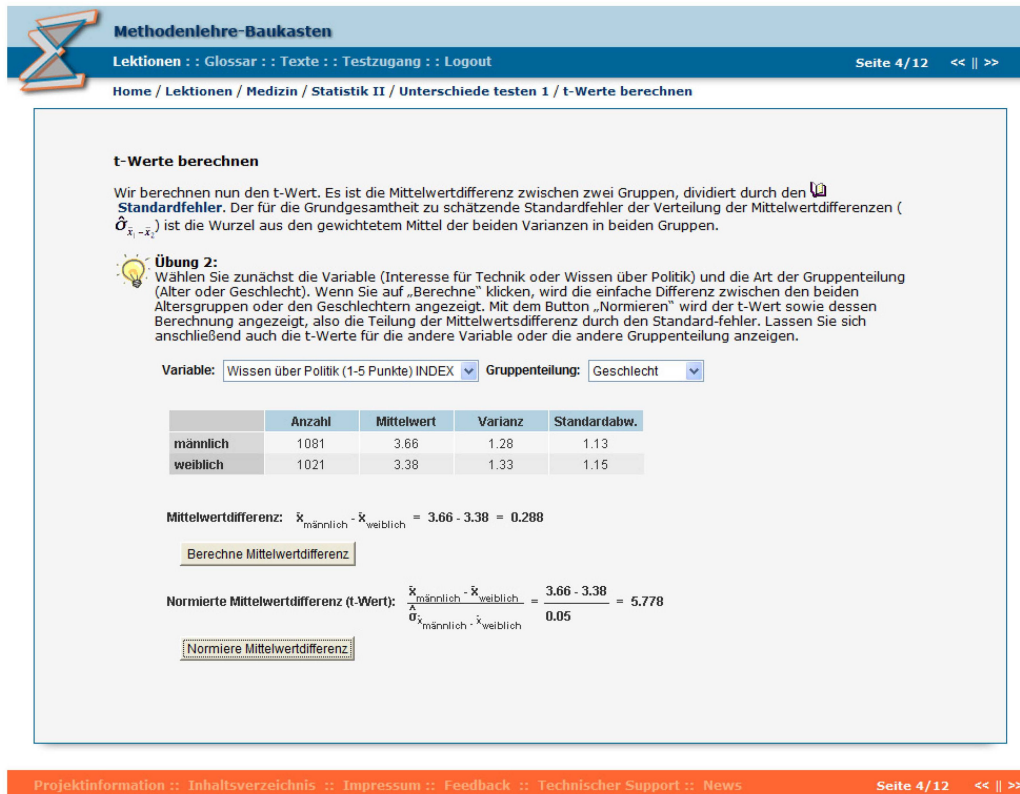
MLBK (Figure 7) is the further development of LernSTATS, and it has been adapted to the subjects psychology, educational science, sociology, economics and medicine. In addition, the module statistics II has been released, covering sample and universe, testing hypotheses, and analysis of variance. Flash interactions are used in addition to Java Applets. Additional modules are from reality to data, data collection methods, specific methods, and experimental methods. Access to the Methodenlehre-Baukasten is charged with a license fee of € 12.00 per person and year.

Discussion

LernSTATS has been criticized in the literature [30]. The concerns also count for MLBK at least to some extent, because every learning page was revised and extended, but in most of the cases only from a didactical and not from a technical point of view.

The graphical user interface of the MLBK appears neat and modern; the navigation through the contents is simple and intuitive. Within the modules there is a wide range of exercises that, unfortunately, are suitable only for practicing. They are not appropriate for individual evaluation of the learning success because the problems offer only a minor grade of complexity; the exercise types are multiple choice and drag and drop. Furthermore, the solutions of the learners are not directly corrected and evaluated. As a result, the learner does not receive any feedback concerning his/her individual knowledge, which is of great importance for the learning success. We

Figure 7: Screenshot of the graphical user interface of Methodenlehre-Baukasten

therefore conclude that MLBK is not suitable for self-learning.

14. MM*Stat / Statistik – Wissenschaftliche Datenanalyse leicht gemacht (Statistics – Scientific Data Analysis Made Simple)

MM*STAT [36] is an e-learning course that is available on CD-ROM [37]. Technically, this course is built up of static html pages (Figure 8). Thus, it can be used both online and offline. The course is provided in German, English, French and Spanish, and it covers the following topcis: basic statistics, one-dimensional frequency distribution, probability calculus, combinatorial methods, random variable, distributions, sampling theory, estimation, statistical tests, two-dimensional frequency distribution, regression, and time series analysis.

Discussion

MM*STAT basically is an electronic textbook, i.e., the content is provided in a digital form. The interactivity of this module is limited to the navigation between the sections. The didactical potential of technology supported teaching is not used at all. True interaction to visualize complex statistical topics are lacking, so are learning units. The course has smaller technical problems (see, e.g., hidden scroll bars in Figure 9), and we were not able to use it with the Firefox browser.

15. Multimedia-Projekt "Neue Statistik"

The learning modules are only available to students of the Fernuniversität in Hagen. However, it seems that the contents of the New Statistics and New Statistics II are used.

16. Neue Statistik II (New Statistics)

Neue Statistik II (New Statistics) is a further development of the project Neue Statistik (New Statistics), and it was funded within the program New Media in Education by the German Ministry of Education and Research. It is based on the e-learning course Statistik interaktiv that is available in book shops [38] and described below. "Neue Statistik II" promises an online overall curriculum for the interactive transfer of statistical teaching learning (http://www.neuestatistik.de/). The project was developed in cooperation of the Statistics Departments at 10 German universities. The learning units are edited in learning modules and cover the following topics: descriptive statistics, probability calculus, point estimation, testing hypotheses, regression, sampling theory, and survival analysis. More than 80 teaching modules are available, and they contain texts from classical textbooks, short animated lectures (Adobe Flash Format), interactive Java applets, formulae, case studies, and exercises with solutions for the statistics lab (http://www.statistiklabor.de/; [39]). Online access is restricted to members and partners of the consortium and their students, including the use of the statistic lab, the individual adaptation of the overall

Figure 8: Screenshot of welcome page of MM*STAT. The content is well structured. Chapters are subdivided in sections, and they are shown after a mouse click on the chapter level.
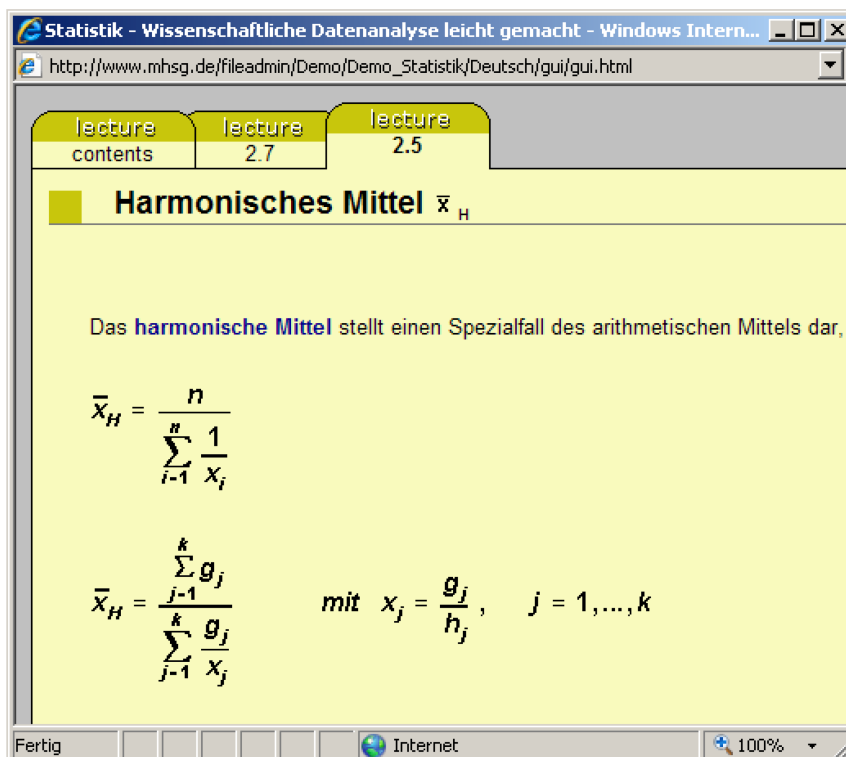

Figure 9: Screenshot of the graphical user interface of MM*STAT. All sections are opened in a new Tab (in this example, Sections 2.7 and 2.5). Open Tabs can be closed by a double click. The active Tab 2.5 only shows a part of the content of the current page. The remaining content can only be seen in a maximized browser window because horizontal and vertical scroll bars are not shown.

curriculum, and the support to conduct digital examinations. Non-members have access only to the statistics lab, few examples, and demonstrations of the learning environment Neue Statistik. For a more detailed description, the reader may refer to [30].

Discussion

The graphical user interface is designed in an appealing fashion, the navigation is consistent and intuitive (Figure 10). The learning content predominantly consists of classic text which often extends to several pages. Therefore, the learner has to scroll while working through the content. The flash animations and Java applets within the learning environment seem to be a little detached from the content because they can be selected only via a separate media gallery. Exercises with sample solutions are found at the end of some pages. However, these are pure math problems and written exercises, and no interactivity or online evaluation with feedback is provided.

17. NUMAS

NUMAS is a web-based teaching and learning system on Numeric Mathematics and Statistics. The project was funded by the German Ministry of Education and Science in the program New Media in Education. It can be used free of charge after registration via http://www.numas.de/. Several modules on numerical mathematics, statistics, and medical statistics are available, and they cover the topics: distributions, descriptive statistics, analytical statistics, survival analysis, diagnostic tests, and study design.

Discussion

The handling of the learning environment is not always intuitive. For example, the navigation of the different learning modules is designed in a way that the topics are highlighted by mouse roll over, but the topic cannot be selected by a mouse click. Instead, the learner has to move to the subsection "zu den Lernobjekten" (to learning objects) first. Software ergonomic guidelines are ignored with respect to navigation and most of the hyperlinks: Predominantly, a click on a link does not result in changing the page or the state but a new window is opened. The intensive use of the learning environment can quickly result in getting lost in the many open windows. The appearance of the interface is heterogeneous: Both type face and color range are not standardized. For example, the start page of NUMAS appears in dark blue, whereas the content pages turn up in mellow lavender and pink. In contrast to this, the sitemap is designed in green and yellow, and the search window is light blue. According to the start page of NUMAS, the system still is in the stage of development. However, the last update of the system was done more than 5 years ago.

The effectiveness of the learning concept has to be doubted. For example, the description of the histogram is presented on one learning page without any visual aids (Figure 11). Only by clicking on "Beispiel" (example), a window pops up which also shows the histograms. Frequent scrolling is required when working through the content. The learning unit statistics contains only very few interactive examples, and the pages include text and formulae only, except of very few exceptions. The exercises only consist of text without interaction. Often, the problems are made up in a way that the learner has to use pencil and paper to solve the problem. For example, "Draw a histogram and a circle diagram." Solutions exist but the learner no feedback is provided concerning his/her solutions.

18. PC-Statistik-Trainer 1.0

The PC-Statistik-Trainer 1.0 is an independent program based on the operating system Windows, and it is available in bookshops [40]. The program includes exercises from the area of descriptive and inductive statistics for students of economics. It is not a complete learning environment but a software program for the practice of statistical problems. Most of the problems are restricted to the mere calculation. The methodology and theoretical background are not explained. In summary, the PC-Statistik-Trainer 1.0 is not useful for autonomous learning of statistics [30], and we therefore refrain from describing this program in greater detail.

19. ROBISYS

The "Rostocker Biometriesystem" (ROBISYS) is an e-learning course developed by Rostock University covering the topics descriptive statistics (module 1), validation of diagnostic procedures (module 2), and randomization methods for controlled clinical trials (module 3). The two last modules were developed within the project MLBK. Thus, they were also funded by the German Ministry of Education and Research in the program New Media in Education.

Discussion

The first module consists of static html pages which exclusively work with Microsoft's Internet Explorer. The user interface appears out of date and disregards didactically important functions, e.g., there is no progress bar (Figure 12). The course includes a page with multiple choice exercises. The learner can validate each problem by mouse click, and the feedback is of the kind "C is wrong, A is correct!" The second and third modules are small programs, and they are completely provided in Adobe Flash Format. This has a substantial drawback: In both modules, each content text is automatically smoothed by Flash. This is fine with short texts, but reading of longer texts can lead to unnecessary strains and tiredness of the eyes. Furthermore, the navigation through the chapters is unfavorably designed. For example, the user is forced to move step by step through the different content pages
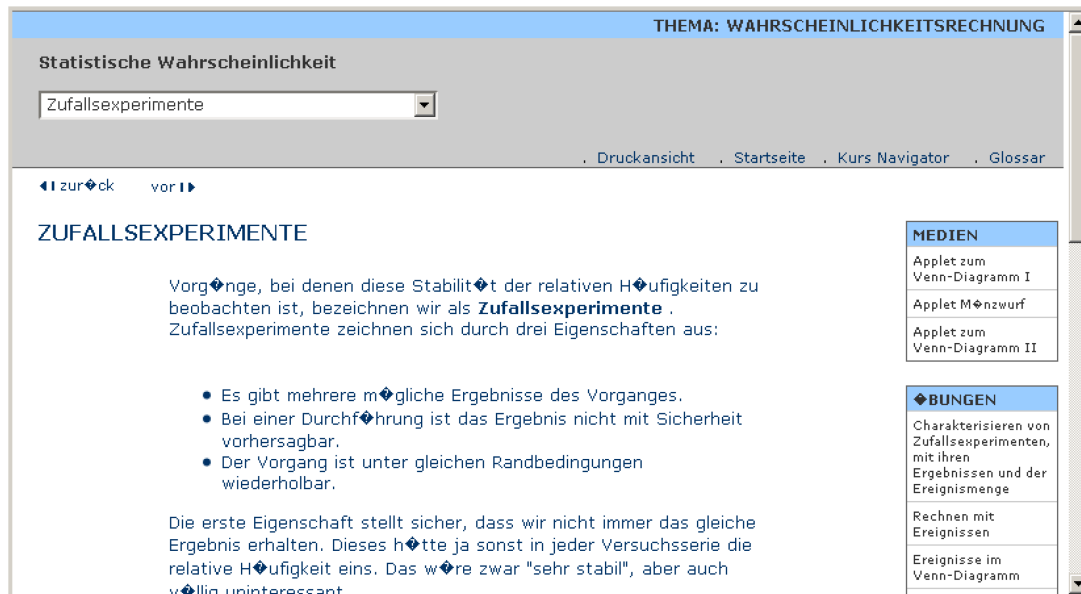
Figure 10: Screenshot of the graphical user interface of Neue Statistik and Neue Statistik II. The graphical user interface is nicely designed. The navigation is intuitive and consistent. Unfortunately, pages are so long that the user has to scroll down regularly. Umlaute and special characters are incorrectly displayed with both the Firefox Browser and the Internet Explorer.
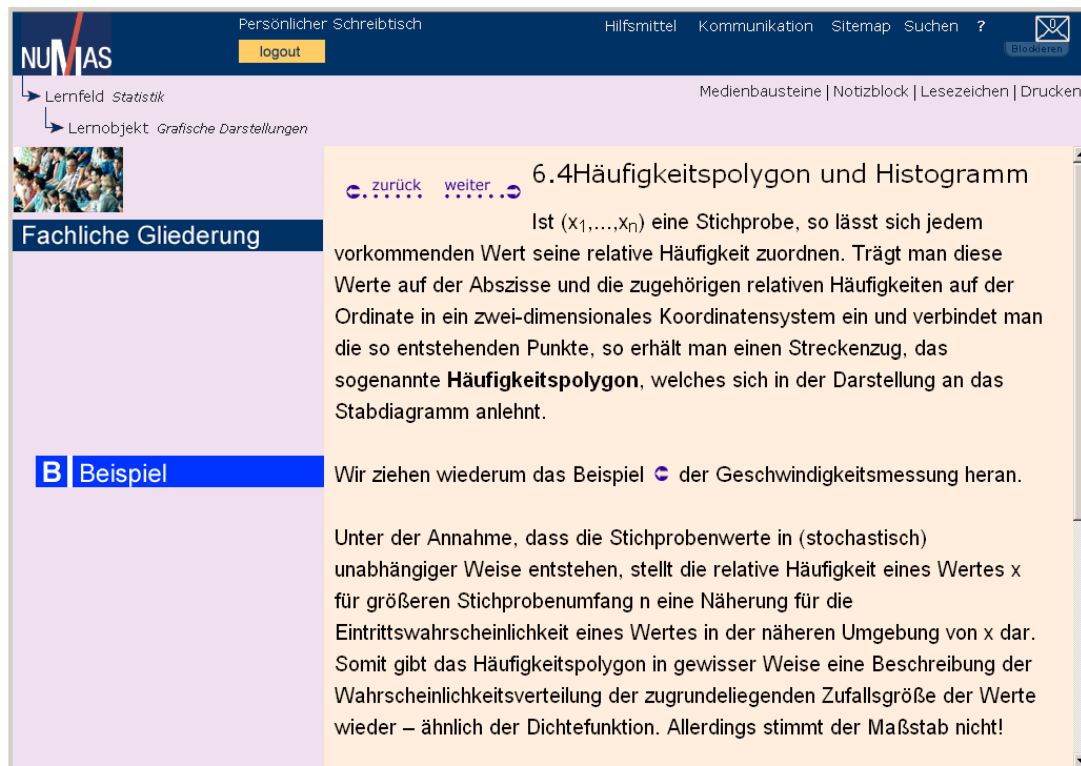

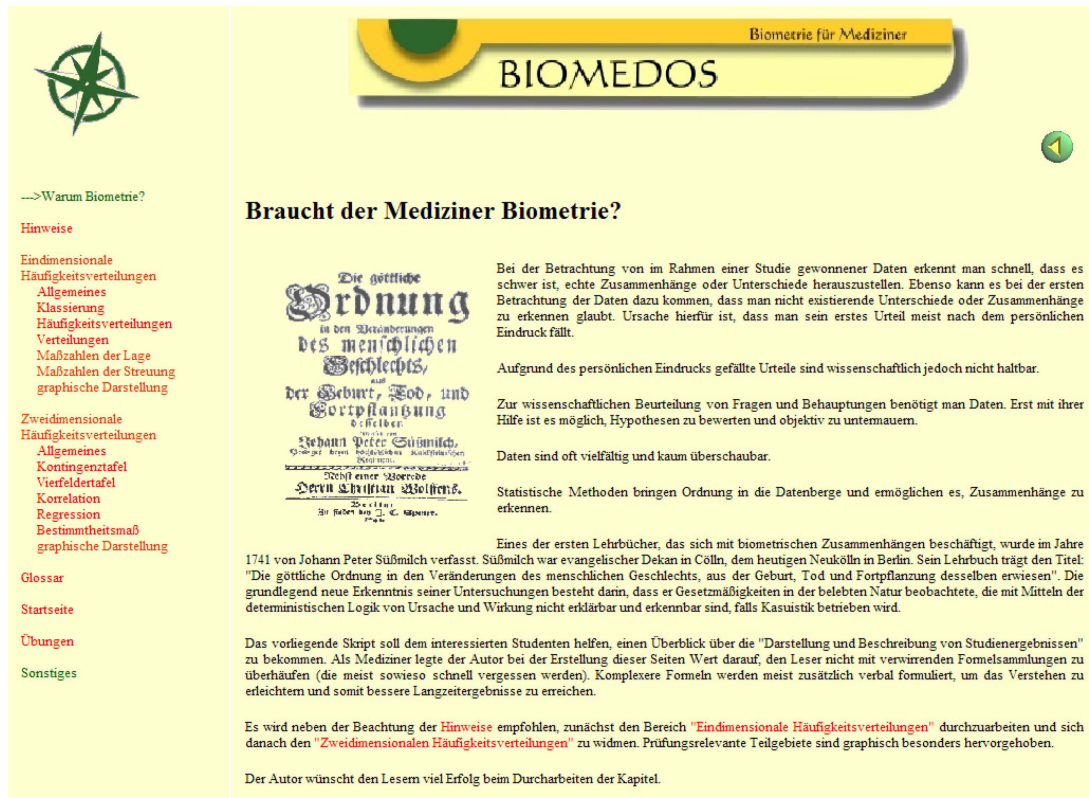Figure 11: Screenshot of the graphical user interface of NUMAS

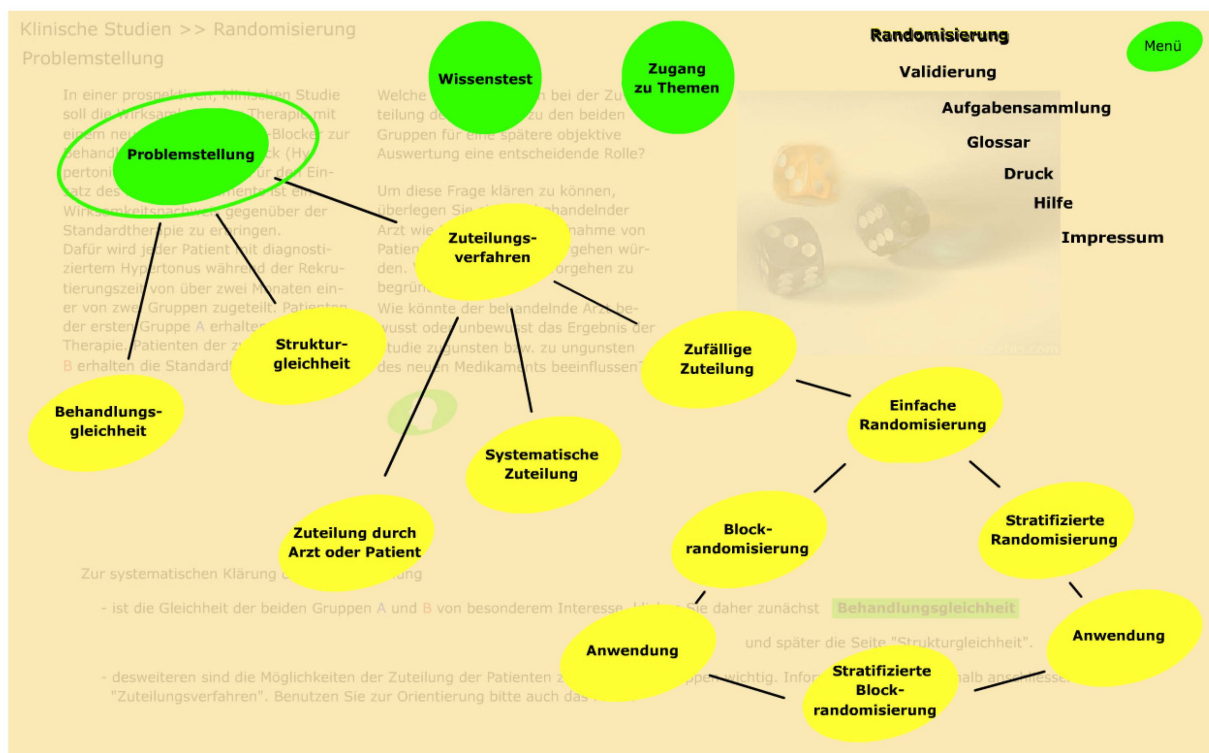Figure 12: Screenshot of the graphical user interface of ROBISYS Biomedos

Figure 13: Screenshot of the graphical user interface of ROBISYS Random. Only the green colored topics are directly available via mouse click.

and cannot skip already known content (Figure 13). Moreover, subsequent pages are directly linked in the text and thus cannot be selected by a forward button.

20. Seeing Statistics

This course has been described in detail in [23], and it is therefore not considered here.

21. Statistik: Beschreibende Statistik und explorative Datenanalyse (Descriptive Statistics and Exploratory Data Analysis)

This e-learning course is available in book shops [38]. It technically uses static html pages that have been generated using Microsoft FrontPage 2.02. Frontpage is an html editor using the WYSIWYG principle. The course can be used both online and offline. Topics covered are one-dimensional and multi-dimensional distributions, location, dispersion and disparity measures, measures of association, regression, theory of price indices, and time series. A detailed description of this course has been given in [30].

Discussion

The course has a clear didactical concept. Each chapter starts with a short text in which the learner is introduced to the topic. Through the hyperlinks theory, example, training, the user is connected to the multimedia content of the learning unit. Theory and practice always consist in a short movie that requires a browser plugin to play real video format. In the training area, content is demonstrated interactively although the title suggest examples requiring calculations. The course has been developed for a screen resolution of 800 × 600 dpi (Figure 14) which is out-of-date. The course has been developed with FrontPage 2.02, which was available with Microsoft Office in 1996. This indicates that is has not been updated and adapted to current technological standards for a longer time period. This may also explain crashing of both the Firefox browser and the Internet Explorer at those parts of the course where multimedia content was embedded.

In summary, the learning program follows a clear didactical concept. However, it does not take into account important hygiene and motivation factors because it is out-of-date. Specifically, we criticize the lack of learning tasks. As a result, the learner cannot train specific content and cannot control his/her progress.

22. StatCenter Psych 3000 Online

This course has been described in detail in [23], and it is therefore not considered here.

23. SurfStat

SurfStat is an online course is the evolution of an existing set of course notes, translated to html to implement hypertext links. Java applets have been added to replace statistical tables and to illustrate concepts. Some units have "progress checks" (i.e., multiple-choice items with feedback). In summary, it is an html-based course that looks like an electronic textbook (Figure 15). It is described in detail in [23], and it is therefore not discussed further here.

24. Visual Bayes

Visual Bayes is an interactive learning program which imparts basic methods for the interpretation and validation of diagnostic tests in a graphic way. It is an independent program which was originally developed for the system software MS-DOS and adapted and newly compiled to Windows in 2003. Ten short chapters cover the topics 2 × 2 tables, test statistics, Bayes formula, predictive values, combination of tests, distributions, sampling, cut-off value, ROC curve, and cost function.
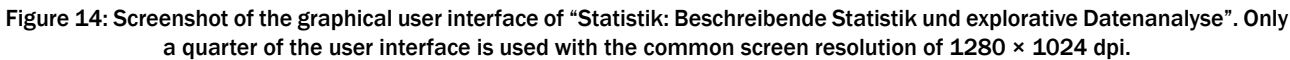
Discussion

The learning program is structured clearly, and it is easy to handle. It contains small exercises which are directly evaluated and commented. Each problem can be repeated arbitrarily often because solutions are not saved. Thus, the problems serve for training in the first place. The graphical user interface of Visual Bayes was originally developed for MS-DOS, and it appears out-of-date. Specifically, the screen resolution is only 640 × 480 dpi and cannot be changed (Figure 16).

25. VisualStat

VisualStat is a small internet platform of Freiburg University. Its aim is the dynamic interactive visualization for selected fields of statistics. It provides four Java applets in addition to useful links to statistics. The applets cover the topics arithmetic mean in the linear model, one-way analysis of variance with two or three groups, and t-test. Thematically seen VisualStat covers just a small field of statistics. The aim is not to provide a complete e-learning course, and we therefore refrain from a detailed discussion.

Discussion

In a systematic literature search, we have identified 25 different e-learning tools for statistics covering many different aspects of the field. It is surprising that German projects published in international peer-reviewed journals have been identified predominantly. The difference between the many German projects and the relatively few e-learning courses in English can probably be explained by the funding initiative "New Media in Education" of the German Ministry of Education and Research. Five of the identified projects have been developed within this program. The financial volume was 2.9 million EUR, and the funding period was April 2001 until December 2004. There were 13 partners and more than 70 scientists involved in the project so that a large number of publica-

Figure 14: Screenshot of the graphical user interface of "Statistik: Beschreibende Statistik und explorative Datenanalyse". Only a quarter of the user interface is used with the common screen resolution of 1280 × 1024 dpi.

Figure 15: Screenshot of the graphical user interface of SurfStat

Figure 16: Screenshot of the graphical user interface of Visual Bayes. The graphical user interface of Visual Bayes has a fixed screen resolution of 640 × 480 dpi, thus uses only a quarter of current common screens. The design appears to be out of date with its historic MS-DOS visual appearance.

tions inevitably is the consequence of this project structure [34].

The e-learning offers differ substantially with respect to target audience, content, amount and quality. The range is from very little interactive content, like *VisualStat*, to extensive learning systems covering all important basics of statistics as *EMILeA-stat* or *Neue Statistik II*. The learning modules that have focused on little content generally have a higher degree of interactivity, e.g., *ROBISYS*.

E-learning courses not meeting basic hygiene factors are expected to be less successful. For example, if the system does not operate flawless, in extreme cases, the demotivation of students can be so big that he/she is not using the learning offer anymore. Hygiene factors for e-learning courses, like a consistent, integrative and intuitive navigation or a precise and clearly arranged structure of contents and pages are important for generating a positive basic attitude in students. These hygiene factors are not met in some of the courses.

One of the most important motivating factors of e-learning courses are demanding and, at the same time, motivating learning tasks [2], [3], [4]. Nevertheless, some of the investigated courses come without any learning tasks. If exercises are available, most of them are provided as text, and the solution is linked to the exercise. This is not different from a presentation in a textbook. None of the exercises gives individual feedback to motivate the student, and no varying degree of complexity has been found.

Furthermore, the level obtained at the end of a specific exercise is not recorded. This means that no information is provided to the student about his/her progress, and the results cannot be used for a continuing control of the learning progress. It always reflects a snapshot of the learning success.

We have expected to identify many courses that are prone to this critique because they have been developed at a time when technical aspects of the course were the main hurdle at the stage of course development. For example, the oncampus factory (http://www.oncampus.de/), a portal providing a learning platform for the Virtual University of Applied Sciences and the Baltic Sea Virtual Campus offers contracts to external course developers only since the beginning of 2007. Subsequently, the most difficult part now is the storyboard which needs to be written either by an author or a professional storyboard writer. The author does not need to take care of any technical aspects. They are provided and adapted according to current standards within the system. This can guarantee sustainability of a course to a greater extent compared to courses which do not make use of such a platform with integrated didactical structure. Platforms like the one provided by oncampus were not available at the time when the courses were implemented that have been compared in this review. It is therefore important to note that some of the courses have been very successful despite the general concerns and have been updated from previous versions (*Neue Statistik II*, *Interaktive*

Multimedia Software). Thus, sustainability of these courses is guaranteed.

In our systematic literature search, we have not been able to identify a single freely available e-learning course for epidemiology or genetic epidemiology. Only few web sites covering some aspects of this area have been found, and only a portion of the available material is suited for self-learning. Because of our involvement in the area of genetic epidemiology, we know that only little online material is available in this area. Specifically, we know of three courses which are based on talks which are linked to the respective slides. These are simple and cheap to produce. The idea to present teaching material in this form is not new, and the Henry Stewart group (http://www.henrystewart.com/) produces and sells this kind of learning material for more than 25 years. However, there is the general question whether this form of teaching should be called e-learning and whether this offer is suitable for self-learning. The recording of lectures is not suitable for thorough self-learning because many didactical aspects, hygiene and motivation factors are not fulfilled. Furthermore, the degree of complexity is rather limited because no learning tasks are available, the navigation is rudimentary, the content can be chosen only roughly, and the speed in the presentations is fixed. To summarize, the didactical possibilities are not used at all.

Despite this critique, it can be of great importance making available digital recordings of lectures to students and interested researchers. If huge distances between lecturer and audience have to be overcome, students and researchers might be able to follow a talk while this would not be possible otherwise. However, we recommend not calling such video recordings e-learning.

The use of electronic media for courses requires adjustments in the way how students learn, they only accept such a technology if they have real advantages. Härdle et al. made the experience that students rarely use forums; even in lectures with a large audience more than 99% of the entries came from the lecturer himself. They also observed a tendency to use inappropriate language, and several forums had to be closed because of insulting postings from the students [26]. Furthermore, the teaching time and effort in the corresponding e-learning environments takes more time than teaching in a face-to-face environment [41]. Specifically, the cost for developing an appropriate e-learning course fulfilling the standard hygiene and motivation factors are very high. Although some colleagues have made bad experiences with e-learning, this method of teaching can reduce the fear of students which is a significant barrier to learning statistics [18]. For example, employing videogame aesthetics can reduce sensations of fear. Another aspect which is important for some of the students is how collaborative learning can be established in an e-learning environment. This again will demand a higher effort from the teacher, who will have to supervise all the discussions among the learners, so that they do not deviate from the intended topic for the lesson [42].

In conclusion, a few years ago, there was hype for e-learning in statistics and biostatistics for the modern education of students. Subsequently, several projects were positively reviewed by funding agencies for developing respective courses. However, as pointed out by Härdle et al. [26], developers were interested in the technically most sophisticated solutions, the lecturers in the proliferation of their materials and the students in an easy way to achieve enough knowledge to pass the exam. Thus, different groups had different goals. The adaptation of existing courses to modern standards has been followed only to a small portion, and sustainability is an important issue. Very few courses have been newly developed, pointing to the fact that the hype is not continuing. Available platforms should be used so that technological development is avoided. These allow the use of common didactical principles, robust and reliable technology.

Notes

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Conflicts of interest

The authors declare that they have no conflicts of interest. They have created an e-learning course for Genetic Epidemiology which has been integrated in the 2nd edition of the book "A Statistical Approach to Genetic Epidemiology: Concepts and Applications" by Andreas Ziegler and Inke R. König, Wiley-VCH, ISBN-13: 978-3-527-32389-0.

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