Biomedical Informatics Education at Charles University in Prague for Undergraduate and Doctoral Degree Studies

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Abstract

The paper describes undergraduate and doctoral degree studies in biomedical informatics at Charles University in Prague. Particularly important in educational programmes and knowledge dissemination is the role of Internet. Therefore we also describe selected e-learning tools as interactive books, wiki teaching materials, Web 2.0-based e-learning tools, the ExaMe system and other teaching tools.

Keywords

education, biomedicine, informatics, e-learning, healthcare

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1 Introduction

Educational programmes in the area that we nowadays refer to as biomedical informatics cover topics from the field of medical informatics and bioinformatics. The conceptual roots of such programmes lead back more than thirty years and the programmes are well established in many countries. The leading role in promoting activities concerning education in biomedical informatics has been given by the International Medical Informatics Association (IMIA) at MEDINFO congresses, special topics conferences and activities of the IMIA working group on Health and Medical Informatics Education. This working group initiated the development of the first IMIA Recommendations on Education in Health and Medical Informatics [1] translated till now into Spanish, Chinese, Italian, Turkish, Czech, and Japanese languages. These recommendations were updated and the second version was published in [2]. Let us mention at least the IMIA conference on medical informatics education held in Prague 1990. It brought together participants from 18 countries and the „Knowledge, Information and Medical Education" proceedings [3] contained more than 60 selected contributions and covered the role of informatics in the medical curriculum and experiences existing in many medical faculties all over the world. This conference highly influenced medical informatics education at medical faculties of Charles University in Prague. After the political changes in Czechoslovakia in the year 1989, education and training in medical informatics at Charles University in Prague have been further developed. The involvement of teachers in several European projects and broader availability of knowledge acquired from national and international contacts with universities, research organizations and working groups of international organizations, e.g. the International Medical Informatics Association (IMIA) and the European Federation for Medical Informatics (EFMI), supported new approaches to medical informatics education. During the 58th World Health Assembly held in Geneva in May 2005, the Ministers of Health of 192 member states of the United Nations approved the so called eHealth Resolution [4] that officially recognizes the added value of the information and communication technologies for health purposes. eHealth technologies opened the doorway to a new type of medical services where healthcare professionals are able to utilize them fully for prevention and management of diseases, lifelong learning and communication with colleagues and patients. Additionally, education and use of eHealth technologies can help to change a passive attitude of patients against their diseases towards a proactive attitude of informed citizens for managing their own health. It is

expected that an increasing development of eHealth applications considering not only electronic but also environmental and economic context [5] will influence also the medical informatics education and training.

2 Education and Training in Biomedical Informatics at Charles University in Prague

Education and training for undergraduate students in medical and biomedical informatics at Charles University in Prague has been provided mainly by medical faculties. The approaches to medical informatics education at five medical faculties of Charles University are different. The first courses in this field were running already more than twenty five years ago on medical faculties nowadays named as the First Faculty of Medicine and the Second Faculty of Medicine. The EuroMISE Centre (European Centre for Medical Informatics, Statistics and Epidemiology), the joint workplace of Charles University and the Academy of Sciences of the Czech Republic, was established in 1994 within the European project with the acronym EuroMISE. The project focused on education in the methodology field of healthcare [6], namely on education in medical informatics, statistics and epidemiology. EuroMISE courses developed in the project were given in English to participants from Central and Eastern European countries in the period of 1994-1998 and more than 120 certificates were passed to participants from these countries at Charles University Aula Magna after successful completions of the courses. Further teaching materials in English were developed within the IT EDUCTRA project (Information Technologies in Education and Training) with versions in German, French, Spanish, and Czech languages [7]. The European projects, textbooks on biomedical informatics education, e.g. [8, 9] and experience with education of biomedical informatics on different levels gathered from relevant literature and conferences, e.g. [10, 11] influenced the nowadays shape of biomedical informatics courses.

The agreement on cooperation of Charles University in Prague and the Academy of Sciences of the Czech Republic in the doctoral degree study programmes in biomedicine was signed on April 23^{rd}, 1997. There are now 20 boards of scientific disciplines in postgraduate doctoral studies in biomedicine at Charles University in Prague. By the initiative of the First Faculty of Medicine the scientific board of Biomedical Informatics was established in the year 2001 [12]. The studies are given in Czech and English languages. The doctoral degree study programmes are provided in a full-time or a combined form. The full-time form lasts four years and the combined form lasts nine years as a maximum. A full-time doctoral student has the status of a student of Charles University in Prague with all the respective legal and social consequences. The requirements for successful completion of the study are:

- to pass the state doctoral examination in a chosen field,
- to defend a thesis, compiled on the basis of own published papers.

The graduates are awarded the academic degree "doctor" (abbreviated as Ph.D. after the name). The scientific board of Biomedical Informatics accepts 10 students on average per year. During full-time or combined studies students have to complete successfully also two courses approved by the scientific board of Biomedical Informatics. These courses mostly use selected e-learning tools that we describe in the next section.

Information about the MEFANET (Medical Faculties NETwork) project can be found at http://www.mefanet.cz/. The MEFANET network involves all medical schools in the Czech Republic and Slovakia. Since 2007 it has been supported by the European Social Fund in the Czech Republic (http://www.esfcr.eu/). The MEFANET project is aiming to develop and to strengthen the cooperation among Czech and Slovak medical faculties, as regards the progress in education of medical and health care disciplines using modern information and communication technologies. The primary objective of the MEFANET project is to facilitate the cooperation among teams from different faculties, and to ensure a horizontal accessibility of electronic teaching tools for both teachers and students. The MEFANET project is certainly not meant to affect or control teaching activities at individual faculties: all targets of the MEFANET project fully respect the independence of individual faculties.

3 Internet and e-learning Tools

E-learning tools can support both undergraduate medical education and doctoral degree study programmes in biomedicine. E-learning, understood as the use of information and communication technology to support and enhance learning practices, has, no doubt, a great impact on learning processes. The main reason for use of e-learning tools is related to flexibility in time and place, limitations of cost and possibility to use e-learning tools by students in their own place and time. Particularly important in educational programmes and knowledge dissemination is the role of the Internet and mainly – from the beginning of the 21^{st} century – the 2^{nd} generation of web services known as Web 2.0. Thanks to rising availability of the Internet and opening of the World Wide Web as a publication, sharing and collaboration platform to wide masses of learners, we have witnessed a shift of e-learning towards so called e-learning 2.0. Further we describe some tools used in undergraduate and doctoral degree education.

3.1 Wiki Teaching Materials at the First Faculty of Medicine

Around 2005, the First Faculty of Medicine dealt with the increasing amount of spontaneously produced electronic educational materials. They were individually created at various departments and greatly varied both in a form and quality. Attempts to share these materials using a web-based portal have lead to petrifaction of the content, including all bugs and inaccuracies. Moreover, the content corresponded to the state of art at the time of its creation. The concept of Reusable Learning Objects (RLO) represented an approach to address these issues. In RLO pieces of information should have been supplemented with metadata and shared in international digital repositories (Ariadne, Edna, Globe, etc.). Unfortunately, such a sophisticated processing of educational materials appeared to be too laborious for busy medical teachers. At the same time, there was the growing amount and quality of information stored in open systems based on the wiki-technology. Thus, the idea of RLO was transformed to wiki at the First Faculty of Medicine.

WikiSkripta/WikiLectures (www.wikiskripta.eu) were established at the First Faculty of Medicine in 2008. The fundamental change compared to existing tools for sharing of educational content was the possibility to involve medical students in creating the materials. The basis of the texts is frequently written by students themselves in a similar way as students do it while preparing for exams. In WikiLectures, the teacher can then rectify the material, complete and verify it. In this way, even errors and inaccuracies widespread among students can be corrected. Contrary to Wikipedia, which served as one of sources of inspiration, WikiLectures are not an encyclopaedia. They rather resemble a textbook consisting of short chapters. Texts are linked together; thus, it is usually not necessary to write each topic more times. Transferring the work of very busy teachers to students and volunteers from among experts brings more effective use of time of both teachers and students who use the results of the cooperative work. The efficacy is even more increased by sharing the project among schools. At the end of 2009, the First Faculty of Medicine opened the project to all 10 medical faculties of the Czech and Slovak Republics. Combination of strengths of individual schools is another great advantage of the project. If the educational content is shared, it is not necessary to prepare the same topic separately at every faculty. The project is open and participating in it is voluntary.

On the other hand, openness of wiki that allows participation of a large number of users represents a potential threat. There is a risk of a fragmented form, lack of pedagogical account, copyright violation etc. Therefore a large, hierarchically structured team of editors is behind the project. Most of its members are able and enthusiastic medical students (nowadays about 50 people). In order to keep a unified vision, style of work, methodology and high standard of communication, administrators of the site arrange frequent meetings with editors ("wiki-teas"). Twice a year, a "wiki-weekend" for the whole editorial team is organized. As a part of these events, team-building activities serve for establishing informal relationships. Great attention is paid to respecting copyrights of inserted content. Educational materials of WikiLectures are available under licenses Creative Commons so that they can be reused even in other projects. The quality of finished articles is to be proven by accredited teachers. WikiLectures have a system for evaluation of articles by teachers and approved contributions are clearly distinguished from unfinished ones. Today, WikiLectures contain more than 4.5 thousands articles; about 10% were approved. The number of active users, i.e. the number of users who made a contribution in the last 30 days, varies around 100. The total number of visits has already exceeded 10 millions. Regarding the field of medical informatics, WikiLectures contain 19 topics. WikiLectures themselves can serve as an example of a successful application of methods of medical informatics in practice.

3.2 Interactive Electronic Books, Videofilms and Audio Presentations of Lectures

In biomedical informatics courses designed for doctoral degree studies we regularly use interactive electronic books, videofilms and audiopresentations of lectures. Based on the knowledge gathered from European projects the EuroMISE Centre of Charles University and the Academy of Sciences CR has started to develop two editions titled "Biomedical Informatics" and "Biomedical Statistics" in the Czech language. The books are published by the Carolinum Printing House of Charles University in Prague and some of them are available in pdf formats for registered users on http://www.euromise.org/. Interactive versions of the books are available only for teachers and students in the courses. Till now three books have been issued in the Biomedical Statistics edition and four books in the Biomedical Informatics edition. The biomedical informatics courses are also enriched by videofilms. For example the videofilm on electronic health record can show an eHealth application running at the University Hospital in Motol presenting the lifelong voice controlled dental cross based on structured electronic health record [13]. Other videofilms show interoperability issues on transfer of data between the hospital information system and an ambulance or information and organizational features of kiosks working at outpatient cardiology departments in the Municipal Hospital in Caslav. Audio presentations of lectures given in five courses with different biomedical informatics topics were developed. Participants of the courses receive relevant lectures for their course on DVD as the material for self-study.

3.3 ExaMe System

Since 1998 the ExaMe system for evaluation of a targeted knowledge is being developed [14]. The idea of the system is based on generalized multiple-choice questions, with no prior restrictions on the number of answers provided to the students. The only restriction is that at least one answer is correct and at least one wrong. This new idea has lead to new concepts of standardization of test results and also to new research problems in statistics. Evaluation by the ExaMe system is performed using fixed or automated tests. A fixed test is prepared by a teacher before evaluation and it is the same for all students in the computer teaching room. An automated test is generated by a computer using random sample of questions and answers. A fixed test is appropriate for evaluation of a group of students in a computer classroom connected to the Internet. An automated test is appropriate for self-evaluation on remote places. Students can pass evaluations by automated tests by themselves and the final results of the tests are displayed immediately. The displayed results also explain to students why some answers were not correct. The ubiquity of the Internet and its World Wide Web applications made it possible to realize the new educational goals in an innovative and creative way.

Experience from biomedical informatics courses running in the last years confirmed great advantages of this e-learning tool for students, e.g.

- easy availability 24 hours a day, because the ExaMe system is the Internet application and the only interface between the ExaME system and its user is the web browser;
- evaluation of knowledge by self-study using Automated tests of the ExaME system with attached explanation of wrong answers. The automated test and attached explanations of wrong answers in the ExaME system lead to deeper understanding of course materials;
- access of students to all results of their tests evaluated by Automatic tests during the course duration as well as for teachers and course organizers;
- easy administration of a course, the possibility to follow results of students not only during the course but also during their self-study;
- possibility to adjust difficulty and evaluation of a test to a purpose of the course and consider different target groups of students in the course.

The ExaMe system is used in all biomedical informatics courses developed for the doctoral degree studies.

3.4 Web 2.0-based e-learning Tools

We have been developing three Web 2.0-based tools suitable for e-learning in doctoral and lifelong education.

The first tool, BLOG, provides information on scientific medical information resources and evidence-based medicine suitable for both undergraduate and doctoral medical education. We have been building up four educational blogs, both in Czech and English, based on the Blogger weblog software. Three of them are password protected, intended for medical students, doctors, and medical information specialists. The fourth, open blog, is aimed at provision of health related information to laymen. We appreciate flexibility and ubiquity of the Blogger system (if an Internet connection is available), so that a teacher can easily update the content if necessary and users can browse it conveniently, without time and place limitations.

The second tool, CLINEWS (Clinical Evidence News), supports translation of scientific knowledge into clinical practice. It is an application based on principles of evidence-based medicine and Web 2.0. The application is framed as an online RSS reader and a database of chosen types of articles from the MEDLINE/PubMed medical database. Tracked documents are randomized controlled trials, systematic reviews with meta-analysis, and clinical practice guidelines. Records are filled in twice a day and they comprise bibliographic data, most of them with abstracts, further they include links to full texts of articles and to related articles in the MEDLINE/PubMed database. The articles are sorted in accordance with MeSH terms. Relative frequencies of MeSH terms assigned to the articles are visualized as a tag cloud. Below the entries, it is possible to put comments and to rate the articles using a 5-star scale. The application is linked to web services providing social bookmarks, including tools for storing and sharing scientific publications like Connotea, CiteULike and Bibsonomy. The beta version of CLINEWS is presently available at http://neo.euromise.cz/clinews.

The third tool provides information aimed at improving decisions of people about their health. It is focused on the domain of cardiology and is called COR (Cardio Online Reader). The principle idea of the COR application is the same it was mentioned in connection with the CLINEWS system: selected types of articles, chosen according to the principles of EBM (i.e. filtering of methodologically reliable and clinical relevant records) have been added to the on-line application. In addition to that the articles entering the system are filtered according to the domain of cardiology. Furthermore, the system is provided by several other improvements (e.g. an annotated time line or an improved search filter). The application is accessible for free at http://neo.euromise.cz/cor.

3.5 Other e-learning Tools

Further we describe three other tools used in biomedical informatics education. The system BAYES helps to explain the Bayesian approach to the design of research studies in health sciences. The central idea of the Bayesian method is the use of study data to update the state of

knowledge about a quantity of interest. In study design, the Bayesian approach explicitly incorporates expressions for the loss resulting from an incorrect decision at the end of the study. The software tool demonstrates the Bayesian approach by generating numeric examples and thus helps students to understand the basic principles of the method including sensitivity and specificity of a test, prevalence of a disease, the ROC curve, etc. The system works in Czech and English languages.

The TECOM system supports teaching of medical decision-making. It utilizes data obtained in the process of treating patients and collected in the database. Students are asked to decide the correct diagnosis of a patient from the database. Students have to choose appropriate questions and from their answers they have to give their subjective probabilities of various diagnoses. The diagnosis with the highest subjective probability is considered as the final decision. The results are evaluated by the traditional error rate technique (percentage of false and correct decisions) and by a prediction coefficient, which measures quality of decision-making processes. The TECOM system can help clinicians to reveal more explicitly their decision-making competencies and enhance their medical knowledge from cases and correct decision stored in the database. The use of the TECOM system for decision-making in cardiology is demonstrated through the database of real cases diagnosed at the Municipal hospital in Caslav.

Clinical practice guidelines (CPGs) play an important role in the translation of the evidence into practice. CPGs vary in the quality and validity of their content when published by many different authorities through Internet. Clinical users need easy-to-use lists and tools for effective look-up. We develop our Catalogue of Clinical Practice Guidelines (CCPG) since 2007. It gathers information about CPGs published in the Czech Republic digitally on the Internet. Each CPG record can be sorted and searched by title, keywords, authors, publishing authorities or ICD or MeSH terms. We have incorporated the last Czech translation of the MeSH thesaurus in the last year. By this MeSH 2011 terms we can link CPG documents to other articles and literature. Not only clinicians and other clinical stuff but also medical students and physicians in the continuing medical education are the target groups of users of CCPG. The bibliographic description of all CPG documents condensed and they are available at our catalogue that can also serve as a source of data for advanced clinical decision support systems when the search for an adequate document for an actual clinical situation is needed. CCPG records contain links to full texts of CPG documents and links to formalized versions of these texts or web applications, which use formalized models. As usually, the formal model for CPG is not a part of commonly published documents, we have to use the full text to create the GLIF model of the CPG document [15]. We tried to use the same approach and technique with other types of documents – mostly educational texts in cardiology or diabetology. In these types of text it seems to be more useful to create only the ontological model of the document without the process structure, because the procedures are not clearly and uniquely described.

The next section shows education of medical informatics and e-learning courses at the Second Faculty of Medicine.

4 Education of Medical Informatics and Blended Learning at the Second Faculty of Medicine

In the time period 2002-2007 medical informatics was taught in the master's program in one term at the Second Faculty of Medicine. Medical informatics courses were covered by 13 two-hours lectures and by 13 two-hours practical exercises. In practical exercises the students had in the years 2002 and 2003 traditional forms of teaching. Attendance at practical exercises was compulsory, materials for practical exercises were available in the traditional paper form. Since 2004, the exercises have been taught in the form of "blended learning" with e-learning support of teaching. All materials for practical exercises were converted into electronic form, results of given tasks were returned by students in electronic form and students had available the electronic version of teaching materials. In case of excused absences students could replace their absence by the self-study of a corresponding lesson. Lectures and examinations throughout the above mentioned time-period were carried out by the Head of the Department only. We tried to compare results of education measured by results of exams (1 – excellent, 2 – very good, 3 – good, 4 – insufficient) between courses given by the traditional way (number of students 402, average mark 1.754) and courses with blended learning (number of students 599, average mark 1.594) using the Mann Whitney nonparametric test for comparing results of exams in these two groups. The test found statistically significant difference in the results of oral examinations before and after the introduction of e-learning tools.

The subject "Dentistry" at the Second Faculty of Medicine is being taught in the fourth year of the curriculum as a 10 days course (60 classes in total) – in Czech and in English (for foreign students) languages. In cooperation with the publishing house Grada there were written two paper books – „Stomatologie" (in Czech) and its translation „Dentistry and Oral Diseases" (in English) [16]. From the web pages of the Department of Paediatric Stomatology, the Second Faculty of Medicine it is possible to connect with the MEFANET portal. Educational materials (PowerPoint presentations, articles, videos etc.) and materials at the MEFANET portal contain 38 contributions in Czech and 17 lectures in English language. This system makes active students´ participation during lessons possible with using both, e-learning lectures and written books. This type of education interconnects the acquired know-

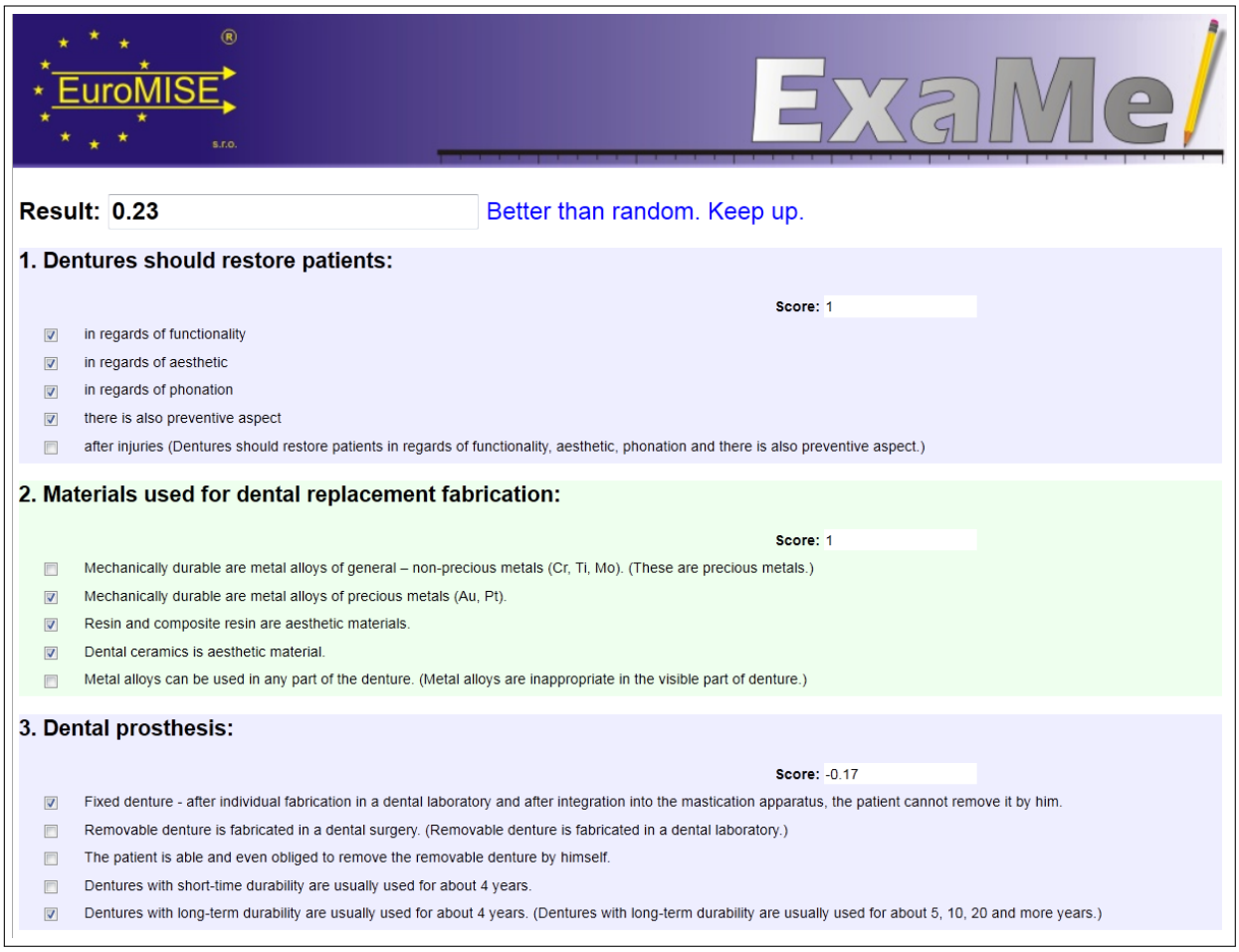

Figure 1: Screen of the ExaMe system.

ledge with the practical training at the same time and it is a consistent preparation for the examination. Evaluation of students´ knowledge can be supported by the ExaMe system (Figure 1) with multiple choice questions derived from books "Stomatologie" (in Czech) and "Dentistry and Oral diseases" (in English).

5 Conclusions

Internet and Web 2.0 based e-learning tools are quickly changing the traditional way of education, training and knowledge dissemination. There are many data and knowledge sources and increasing possibilities for their use in education and training mainly in the English language. Multimedia linked to clinical cases can be stored in digital educational libraries [17]. However, the use of these sources in national languages is also very important. We described approaches to biomedical informatics education in undergraduate and doctoral studies held in Czech and English languages at Charles University in Prague and different e-learning tools supporting educational processes.

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