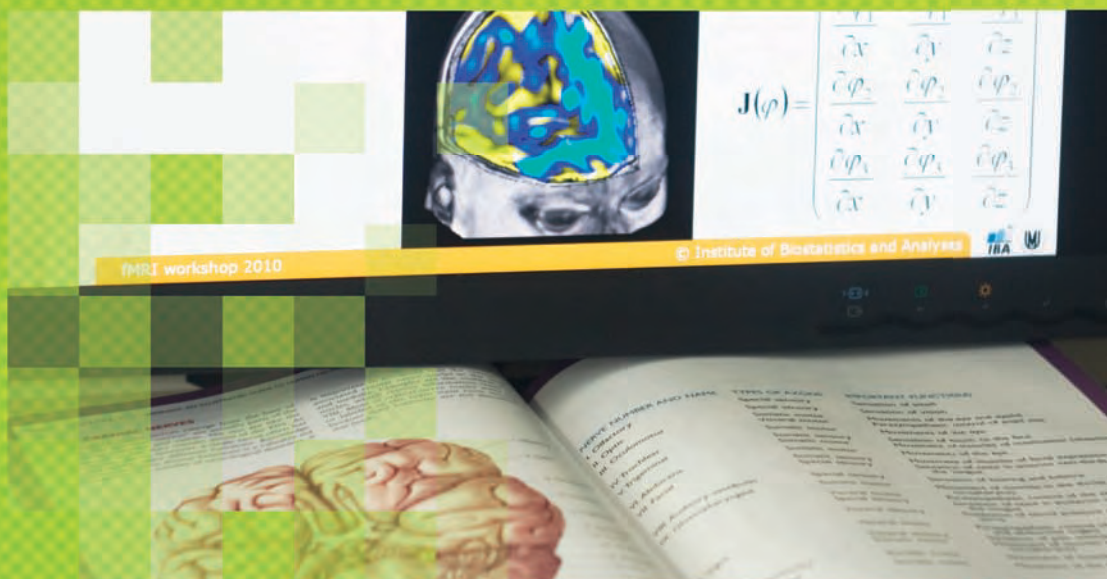


MEFANET report 03

Medical teaching with the use of advanced technology



Editors:

Daniel Schwarz

Martin Komenda

Stanislav Štípek

Vladimír Mihál

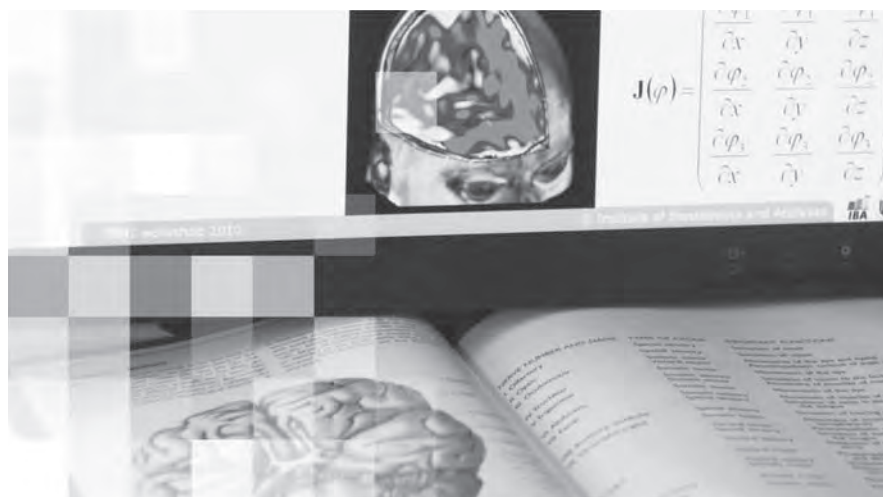
Ladislav Dušek



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Daniel Schwarz
Martin Komenda
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Vladimír Mihál
Ladislav Dušek

Institute of Biostatistics and Analyses,
Masaryk University
phone: +420 549 49 2854, fax: +420 549 49 2855, e-mail: schwarz@iba.muni.cz

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PREFACE

Dear colleagues and students,

the network of Czech and Slovak medical faculties and cooperating institutions has been growing quickly and so has tradition of the MEFANET conference. We are pleased that by means of the MEFANET Report 03 we can look back at the 3rd year, which took place in November 2009 in hotel Voronez, Brno. And while reading it, we can look forward to the 4th year, which will be held at the same place on November 24–25, 2010.

MEFANET 2009 confirmed rising interest in implementation of modern information and communication technologies into education of students of medicine and physicians. Efforts of several enthusiasts have gradually turned into an official cooperation of all Czech and Slovak medical faculties and other institutions involved in education of health care professionals, which has been covered by agreement on cooperation signed by deans of all participating faculties and supported by the European Education for Competiveness Operational Programme.

The 3rd year of the MEFANET conference dealt with usual topics associated with e-learning and ICT in medical education and also focused on assessment of impact of this phenomenon on a specific field of medicine – oncology. This field helps human population face diseases that are responsible for 7.5 million deaths per year worldwide. Research and clinical practice have produced high amounts of data and results that may be used not only for improvement of health care, but also for education and training of physicians and students of medicine. To transfer this goal into practice, an intensive cooperation of experts in oncology and information technologies is necessary.

Contributions presented during the conference and, after all, in this Report, also illustrate a wide range of modern technologies and tools that have become a standard part of teaching at medical faculties – from virtual instruments and e-courses over surgery live broadcasting to systems for testing of students' knowledge. A significant contribution of students themselves to creation of teaching materials and their participation in various e-learning projects must also be pointed out. The MEFANET report 03 merges the finally selected fourteen papers into two sections:

- A: Simulation, decision algorithms, databases and guidelines in medical education
- B: Educational portals, learning management systems and e-testing agenda in medical education

We hope that you will find content of this Report beneficial and inspiring for your work and, last but not least, we are looking forward to seeing you in November in Brno at the conference MEFANET 2010.



Daniel Schwarz Martin Komenda Ladislav Dušek Stanislav Štípek Vladimír Mihál

01

MEFANET 2009 PRESENTED E-LEARNING AS AN IMPORTANT PART OF EDUCATION IN ONCOLOGY

Komenda M., Gregor J., Schwarz D.

Institute of Biostatistics and Analyses, Masaryk University

Abstract

Third year of the MEFANET conference was held in hotel Voroněž (Brno Czech Republic), on November 25–27, 2009. E-learning and health informatics in medical education was selected as the main topic by the Programme Committee. Besides methodological and educational aspects of e-learning, the conference also focused on impact of this phenomenon in a specific field of medicine – oncology. The first day programme was enriched, as well as in previous years, by videoconference contribution – this time internet lines connected participants with Canada.

Ongoing cooperation of Czech and Slovak faculties of medicine has appeared to be very successful. This fact is documented, among others, by a high number of teachers, students, and others interested in electronic support of education, who met at the end of November in Brno. An attractive presentation of topics in individual sessions often led to a brisk discussion, which continued in corridors. The MEFANET 2009 conference offered traditional sessions and workshops addicted to information and communication technologies and their use in teaching, as well as opinions of students on effects and integration of ICT in medical study programmes. New item in the conference programme was a discussion panel associated with recent “hot topic” regarding ethics and legislation aspects of electronic publishing.

Conference opening

The conference was opened with a contribution by prof. Stanislav Stipek, MD, PhD, (1st Faculty of Medicine at the Charles University, Prague). In his speech he returned to the very beginning of the MEFANET network and to the original idea of a simple collection of educational materials. The network currently connects seven Czech

and three Slovak faculties of medicine and early accession of further cooperating institutions has been awaited. All participants were officially welcomed and individual chairmen of the first session were introduced: prof. Jan Zaloudik, MD, PhD (dean of the Faculty of Medicine at the Masaryk University, Brno), prof. Vladimír Mihal, MD, PhD (vice-dean of the Faculty of Medicine at the Palacký University, Olomouc), prof. Ivo Provazník, PhD (vice-dean of the Faculty of Electrical Engineering and Communication at the Brno University of Technology), and assoc. prof. Ladislav Dusek, PhD (head of the MEFANET Coordinating Council). Prof. Zaloudik subsequently welcomed participants of the conference as well and remarked that he was looking forward to enjoying the MEFANET conference from the position of an ordinary participant in the future.

Plenary session I – MEFANET in past, present, and future

The Plenary session I was opened by assoc. prof. Dusek. He positively evaluated the 3-year period of MEFANET existence. The original idea to establish cooperation within the frame of education development



Plenary session I chairmen.

using modern information technologies and e-learning has turned to a stable and growing international network of medical faculties. Assoc. prof. Dusek emphasized particularly ability to reach agreement, determine priorities of cooperation, and horizontal structure of the network. Further progress should include ensuring guarantee and quality of the publications content, unification of working procedures, and strengthening user's position. Legislation aspects and associated respecting of designed rules cannot be omitted as well, as authors of electronic publications often break them, either intentionally or not.

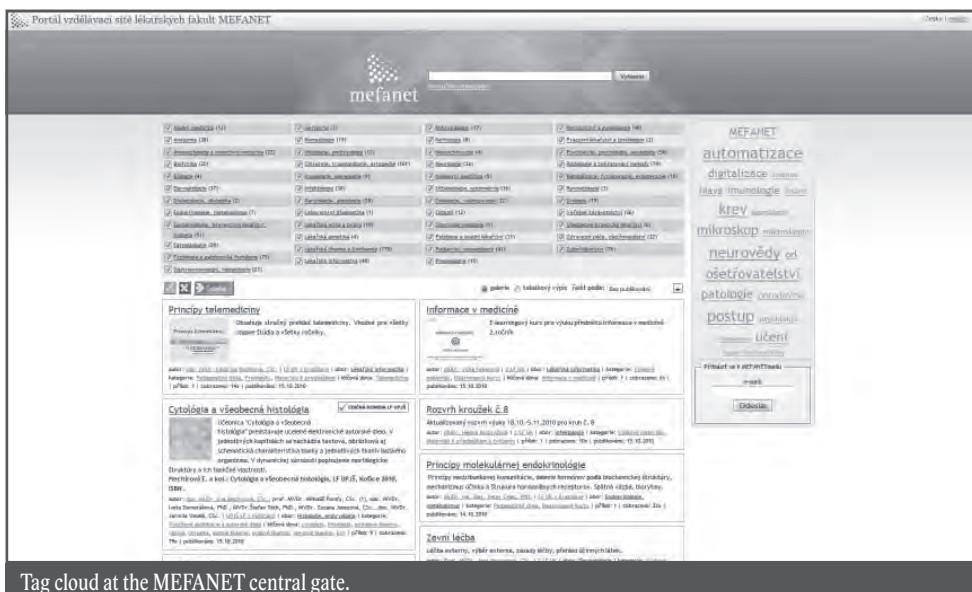
Daniel Schwarz, PhD (Institute of Biostatistics and Analyses at the Masaryk University, Brno) presented new elements and functionalities in the common portal platform of the MEFANET network. Its main objective has still been sharing electronic materials and their availability for network users. A portal solution has been selected for the whole network. It has been installed at all of ten medical faculties, which administer it on their own. Some elements, however, are common for all portals. Last updates in the portals have involved tag clouds, users' discussion, pictograms of the Creative Commons licence, users' evaluation of individual contributions and pictorial case reports.

Solution of content categorization by means of the tag clouds offers reader their list, so that key words that are used by portal users most frequently are displayed with the largest font. Another new function brings user into action as well. The user may participate in contributions evaluation and may also discuss them with other users.

The opening plenary session was concluded by prof. Mesko (Jessenius Faculty of Medicine at the Comenius University, Martin), who presented e-learning portal of the Slovak Medical Chamber. He mentioned reasons for the portal implementation caused by an essential change in recent education paradigm. Goal of the project was obvious due to absence of a comprehensive lifetime education in Slovakia, i.e. ensure physicians access to the latest medical research information. The e-learning portal should serve not only as a tool for coordination of educational activities, but also as a system for testing and allotting credits by means of autodidactic tests.

Plenary session II – Contribution of students to creation of educational materials

Very attractive and interesting Plenary session II was addicted to active participation



Tag cloud at the MEFANET central gate.

of students in the process of educational materials creation. Authors from the 1st Faculty of Medicine at the Charles University presented contribution with a slightly controversial title “MEFANET is dead, vivat MEFANET! Will MEFANET take advantage of new technologies for learning support?” An interesting alternative of using the Web 2.0 technologies for a cooperative creation and storage of medical teaching materials is “Wikiskripta”. The project is based on the familiar wiki technology. Introduction of this tool evoked a plentiful discussion concerning particularly the problem how to ensure a stable quality, which is undoubtedly required for teaching materials.

Petr Stourac, MD, from the Faculty of Medicine in Brno introduced the project Akutne.cz.

He described technical background of the education and publication portal, which was developed with the aim to bring emergency medicine closer to pre- and postgraduate students. The presentation was enriched with a live broadcast of the eye surgery. Modern information technologies allow for a reliable distribution of the surgery broadcast without delay at the web portal Akutne.cz, where it is available for students. Advantage of this technology was illustrated by a live interview with the leading surgeon before the surgery. This topic was also widely discussed during the afternoon workshop focused on active participation of students of medicine in the development of extensive e-learning projects.

The plenary session was closed by assoc. prof. Josef Feit, MD, PhD (Faculty of Medicine, Brno) who described creation of pictorial case reports in atlases. A general introduction was followed by concrete outputs of students' work, who presented the whole process from the task selection and setting to the final case report in the atlas.

Contribution evaluation and discussion.



Stephen Downes and his presentation entitled New Tools for Personal Learning.

Videoconference

Videoconference has become a traditional part of the MEFANET conference. Internet lines connected the conference participants with Stephen Downes, MA, a world-recognized expert in the field of online learning, who works in National Research Council, Institute for Information Technology in Canada. Stephen Downes showed in his presentation how to develop new technologies, so that they would be adaptable in a quickly changing and complicated world. Education is in his opinion rather a question of personal development than acquiring knowledge and memorizing. This would enable us working with acquired knowledge more efficiently.

E-learning in oncology: a way to teach health care standards

Assoc. prof. Ladislav Dusek, PhD, introduced chairmen of the oncology section: prof. Jiri Vorlicek, PhD, and assoc. prof. Jindrich Finek, PhD. Current situation and status of Czech oncology and cancer care was the main topic of presentation by prof. Vorlicek, head of the Czech Society for Oncology. Assoc. prof. Dusek mentioned

in his contribution problems of processing of existing clinical data, which is often unused. Since amount of such data is very large, education should be focused on their processing and development of tools and software that support availability of resulting materials. Web portal allowing for a visualization of cancer epidemiology data was introduced by Dr. Jan Muzik (Institute of Biostatistics and Analyses MU, Brno). A similar portal solution in Slovakia with a lower amount of data was subject of contribution by prof. Dalibor Ondrus, PhD. Further presentations narrowly related with ideas and tools for data collection and their employment in teaching. Authors across the MEFANET network described situation in their institutions and familiarized audience with their solution for collection and further use of clinical data.

Ethic and legislative aspects of creation of electronic materials for education in medical study programmes

The second day of the conference was opened by a discussion panel on the topic, which has been very important in times of

quickly developing electronic publication activities – ethics, legislation, and author rights associated with electronic publishing on the internet. The panel was led by Zdena Dohnalkova, MSc (MU Campus Library), Dagmar Brechlerova, PhD (EuroMISE centre), assoc. prof. Judita Kinkorova (Technology Centre AS CR), Radek Policar, MSc (Masaryk Memorial Cancer Institute), and Radim Polcak, PhD (Faculty of Law, MU). A high number of very specific questions demonstrated that this topic has been very hot nowadays and a continuous (self)education of all, who use the internet as an information source for their publications and simultaneously as their publishing medium, is very important.

Telemedicine is not a topic only for radiologists

Telemedicine, in other words remote teaching of medicine, is a field that also fully uses progress of modern information and communication technologies. A sufficiently powerful technology makes broadcasting via the internet very simple, which is very suitable supplement of teaching, as documented by presentations by Tomas Junek, MSc (Faculty of Medicine at the CU in Pilsen) and Frantisek Vanek, MSc (1st Faculty of Medicine at the CU in Prague). Jaroslav Majernik, PhD (Faculty of Medicine, JPSU in Kosice) introduced a project of virtual hospital that helps students better understand advantages of electronic health care system and relationships among the patient, physicians, hospital, and health care payer. Virtual case reports have progressed a similar way, as illustrated in the contribution of prof. Ales Ryska, MD, PhD (Faculty of Medicine, Hradec Kralove). The topic of telemedicine was also involved in the parallel symposium Telehematology, led by prof. Miroslav Penka, MD, PhD, from the Faculty of Medicine, Brno. He introduced participants general problems of this field and practical demonstrations by individual users followed.

Creation of e-learning materials and evaluation of their benefits

Not less than three sessions of the second day of the conference were addicted to the process of e-learning materials creation, use, and evaluation in medical education. Employment of attractive elements and modern technologies were discussed in the section Simulation, animation, and other activating elements in e-learning. Thanks to them users may familiarize with microscopic techniques in various fields of medicine, walk around cellular structures, or remind human anatomy. An essential aspect of electronic materials is their continuous update based on the latest scientific findings.

Parallel section included methodological and pedagogic aspects of e-learning. New systems for teaching (WikiSkripta, portal of the Czech Dental Chamber) and testing of students' knowledge (Opus Sapientiae, ExaMe) were presented.

Assessment of a multiyear work with courses in medical faculties and monitoring tools were the main contents of the last afternoon section. Authors introduced their results and experience with employment of e-learning in teaching. Detailed statistics clearly demonstrated that electronic materials have been popular and widely used by students. Number of e-courses has recently growing up and the medical faculties do not stay behind.

MEFANET Coordination Council meeting

The official conference programme was followed by a public meeting of the MEFANET Coordination Council. Representatives of medical faculties positively assessed the whole conference and rising level of contributions. Accession of a new member – Faculty of Military Health Sciences at the Military Schools in Hradec Kralove – was unanimously approved by the Coordination

Council. Therefore, MEFANET has become a network of 11 medical faculties. Changes in the network map of fields were approved as well. In spite of the demanding 2-day programme the meeting took place in a very pleasant and friendly atmosphere.

Term of the 4th year of the MEFANET conference was scheduled to November 24–25, 2010. We believe that level of contributions will be at least as high as this year. By that time we wish all participants and modern teaching methods enthusiasts many accomplishments in improvement and innovation of teaching courses.

Bioinformatics in Genomic and Proteomic Data

A satellite conference Bioinformatics in Genomic and Proteomic Data took place simultaneously with the MEFANET conference. Participants, mainly students, had a great opportunity to see presentations of top European experts from Great Britain, Switzerland, Czech Republic, and Belgium. The conference was held in cooperation of the Institute of Biostatistics and Analyses and the British Embassy in Prague under the auspices of the British ambassador to the Czech Republic, Mrs. Sian MacLeod. Mrs. MacLeod met deans of the Faculty of Medicine and Faculty of Science and then opened the conference. She emphasized role of bioinformatics in modern biomedical research, use of new scientific findings and technologies in practice, and importance of cooperation of leading experts to keep European scientific research competitiveness. She also shortly introduced the system of science support in Great Britain.

The conference was aimed to introduce latest statistical methods for processing genomic and proteomic data and establish

long-term international cooperation in this field. Following topics were presented by individual authors:

1. Analysis of express genomic data, data normalization and processing.
2. Looking for differently expressed genes
3. Clustering and prediction in genomics and proteomics.
4. Computational epigenetics.
5. Meta-analysis of microarray data.
6. Analysis of metabolic and signal pathways.
7. Databases of genomic and proteomic data.
8. Data analysis in mass spectrometry.
9. Phylogenesis.



The British ambassador to the Czech Republic, Mrs. Sian MacLeod, opens the conference.

A

**SIMULATION,
DECISION
ALGORITHMS,
DATABASES
AND GUIDELINES
IN MEDICAL
EDUCATION**



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02

DATA BASED E-LEARNING COMPONENTS OF THE CZECH NATIONAL CANCER CONTROL PROGRAMME

Teaching based on real clinical data as a way how to reduce cancer care disparities

Dušek L.¹, Brabec P.¹, Klimeš D.¹, Schwarz D.¹, Májek O.¹, Mužík J.¹, Pavlík T.¹, Feltl D.², Vyzula R.³, Fínek J.⁴, Babjuk M.⁵, Vorlíček J.⁶

¹ *Institute of Biostatistics and Analyses, Masaryk University, Brno*

² *Faculty Hospital Ostrava*

³ *Masaryk Memorial Cancer Institute, Brno*

⁴ *Faculty Hospital Plzeň*

⁵ *Faculty Hospital Motol, Prague*

⁶ *President of the Czech Society for Oncology*

Abstract

This article is aimed as comprehensive summary of electronic educational tools and information sources employed in cancer care teaching programmes of the Czech Republic. The organization scheme of the Czech cancer management has been remarkably changed in recent years, which has inevitably impacted upon distribution of care and patients. Current disparities in cancer care influence prevention and early diagnostics, as well as management of care for advanced disease. That is why the attention of official educational strategy of medical societies is paid namely to e-learning tools based on processing of clinical and population data. Implementation of these instruments has recently closed the 1st phase of the learning programme designed for the network of the Czech Comprehensive Cancer Centres (CCCs). Educational content of the portals presenting the National Cancer Control Programme forms a core component of the strategy (www.linkos.cz, www.onconet.cz). E-learning interactive tools operating over cancer population data and registries are described (www.svod.cz, www.uroweb.cz). The summary also addresses learning tools focused on health technology assessment (set of clinical registries; www.registry.cz), healthcare standardizing tools like electronic library of chemotherapy regimens and its interactive learning workspace (www.dios.registry.cz), and educational tools supporting cancer prevention. The paper defines content areas which are needed to be supported by e-learning linked to the clinical practice. The Czech National Cancer Control Programme initiated many learning projects which help in disseminating awareness about cancer healthcare in the lay public and in promoting cancer prevention strategy.

Keywords

cancer care, e-learning, Czech Republic

Introduction

In recent years, several comprehensive worldwide and European summaries of cancer incidence and prevalence have been published^[1–3]. According to Ferlay et al.^[3] there

were 3,191,000 diagnosed cancer cases (excluding nonmelanoma skin cancer) and 1,703,000 deaths from cancer in Europe in 2006. The Czech Republic is unfortunately ranked among the countries with

the highest cancer burden in Europe and worldwide^[4]. All neoplasms, including non-melanoma skin cancer, reached crude incidence rate of almost 736 cases per 100,000 men and 648 cases per 100,000 women in 2007. The annual mortality rate exceeded 263 deaths per 100,000 population; each year, more than 27,000 persons die of cancer. Overall incidence of malignancies has increased during the last decade with the growth index +26.4% (1997–2007).

Therefore, the cancer is an important public health problem with only partially effective measures how to diminish the continuous growth of burden. The Czech National Cancer Control Programme implemented many activities in order to minimize rise in cancer incidence and consequences of cancer mortality. The programme also helps in disseminating better awareness about cancer healthcare in the lay public and in promoting cancer prevention strategy. The programme was initiated in 2003 in accordance with the conditions and needs of the Czech Republic, and in compliance with the conclusions of WHO Consultation on Strategies to Improve and Strengthen Cancer Control Programmes in Europe, held on 25th–28th November 2003 in Geneva, Switzerland. The programme was developed by the representatives of the Czech Society for Oncology, the League Against Cancer and the Ministry of Health. The programme has been built on four principal cornerstones:

- support by expert medical societies;
- regionally distributed network of Comprehensive Cancer Centres;
- information background, health technology assessment, quality monitoring;
- lifelong learning and effective communication.

Medical professionals and healthcare managers represent important target group of any cancer control programme. Lifelong learning is necessary regarding dynamic progress in the field of diagnostic and therapeutic technologies. Moreover, the cancer care is associated with a wide spectrum

of medical and scientific disciplines and requires up to date educational support. In the last decade numerous important trends significantly changed cancer care management which is currently more closely linked to the research base. Completely new strategies and therapeutic possibilities emerged^[5]. Remarkable progress in the fields of genomics, proteomics and bioinformatics has recently incorporated data analysis to the clinical standards. In the era of personalized medicine, multivariate predictive models form a base for validation of many parameters which are associated with therapeutic standards and which in fact influence therapeutic strategy adopted in individual patients. Recent clinical practice generates heterogeneous data sets of large volume which should be effectively processed in real time and return to the clinical process as a base for decision making^[6, 7]. In such environment, effective educational support cannot be omitted.

This article is aimed as comprehensive summary of electronic educational tools and information sources for the Czech cancer care teaching programmes. The attention is paid namely to functional e-learning tools based on processing of clinical and population data. Our paper also defines content areas which are needed to be supported by e-learning tools. The linkage between teaching and clinical practice is critically discussed and the importance of the context in which such education occurs is stressed.

Data Sources and Methods

The Czech Society for Oncology (CSO) has based its educational strategy on the combination of population-based and clinical registries, and makes every effort to develop it further in cooperation with the healthcare payers. The system is based on real data which is collected directly at clinical practice. The following paragraphs provide an overview of the main data sources used.

As a standard part of population monitoring, the Czech Statistical Office admin-

istrates data on the demographic structure of the Czech population and makes it available on its website^[8, 9]. This fully consolidated data source describes the main demographic characteristics of the Czech population, such as the total population, the age structure, life expectancy, as well as predictions up to 2050. The Death Records Database serves as a source of ascertaining population mortality from malignant neoplasms in the Czech Republic; this database is also maintained by the Czech Statistical Office in compliance with the international methodology and based on the data from the Death Certificate (ICD-10 classification).^[10]

The Czech National Cancer Registry (CNCR) is the principal source of data on the epidemiology of malignant tumours. CNCR has become an indispensable part of the complex cancer care, containing more than 1.4 million records over the period 1976–2005 and covering the entire Czech population. The registration of malignant neoplasms is stipulated by the legislation and is obligatory. The CNCR is a part of the National Health Information System (NHIS) and is administered by the Institute of Health Information and Statistics of the Czech Republic^[11]. The CNCR is accepted as a key database component of the Czech National Cancer Control Programme, designated to report regular and timely estimates of the cancer burden in the Czech population.

Three cancer screening programmes are currently in operation, focusing on breast cancer, colorectal cancer and cervical cancer. These programmes benefit from a solid background comprising population data, making it possible to assess their nationwide impact. Moreover, specific information systems for cancer screening programmes have been developed, focusing on the collection of data on performed examinations and their results. This so-called data audit of screening programmes serves for regular assessment of screening performance and for education as well.

Clinical registries of the CSO represent as the main source of clinical data. The registries provide a reliable description of the clinical practice, focusing on the collection and analysis of data on diagnostic and therapeutic procedures, or monitoring the results of a specific type of treatment. These clinical databases in combination with the Czech National Cancer Registry constitute a complex source of data, making it possible to assess not only the healthcare results, but also population-based indicators of quality, including the nationwide and regional availability of health care.

Some information cannot be obtained from commonly available data sources; for example, the time trends in the probability of relapse/progression of primary malignant disease, or the probability of application of higher-line treatments in differently affected cancer patients. In these cases, predictions and assessments are made by an expert panel of the CSO. Each year, the expert panel processes relevant data from the above-mentioned sources in order to answer clearly defined questions^[4].

In 2010, the new concept and structure of electronic documentation of cancer patient was developed by the expert panel of the CSO. Recently, this information system has been progressively implemented in everyday practice of the Czech health facilities; in this way, data previously reported to health-care payers only will become available for analyses. The combination of these reports with diagnostic records within CNCR creates a brand new information system, making very detailed clinical data readily available. The project called “Fusion of CNCR and health care payers data” was successfully accomplished in two major hospitals and led to the analysis of more than 510,000 complete and comprehensive records on the treatment of cancer patients.

Most of the electronic learning tools run over these, continuously changing, databases and information systems. The whole concept employs mainly web-based technologies. The web portals are placed on

a server with Linux operation system, MySQL relational databases are used as data storage for user accounts and temporary data. The Apache web servers are compiled with PHP scripting module. Communication is based on web services standards (XML, SOAP and WSDL). User interface was designed and realized by a combination of techniques: HTML templates, JavaScript and CSS. PHP is the main scripting language used to build dynamic web pages. XSLT style sheets are used to visualise and transform XML files. An XSLT document describes data transformations that are to be performed on nodes of an XML document. Using XSLT, an XML document can be transformed into a variety of text formats (XML, HTML, PDF, etc.).

The hardware requirement of this solution is reasonable in relation to today's hardware capabilities. The host server contains two processors Intel Xeon 2.8GHz, two 35GB SCSI discs for the OS and one 75GB SCSI disc for data, which most typically requires approximately 20MB disk space. One physical server hosts several websites, databases and learning tools. Management of the educational portals has two levels: Web-Master with full access to all functions of the portal (main administrator) and administrators with access to specific parts of the portal (management of news, tutor – student interaction, etc.).

All functions of the educational tools are freely available to all users. Registration is needed only rarely in order to access complete functionality requiring direct access to the clinical data. The registration is authorized by the system administrator who will send back the registration data. The educational portals are available in both the Czech and English versions.

Results

The Czech Society for Oncology makes effort to ensure unrestricted availability of important information sources and to ensure development of educational content over the data. Only functional educational

tools are presented here. All mentioned projects are accessible in the portal of educational network established by the Czech and Slovak medical faculties, MEFANET^[12].

National Cancer Control Programme Online (www.onconet.cz) and the main communication portal of the Czech Society for Oncology (www.linkos.cz):

- These portals communicate, among others, the targets of the National Cancer Control Programmes and the way these targets are being accomplished. The portal www.linkos.cz contains a section for health professionals and a separate section for patients, their families and friends. The portal www.onconet.cz has been designed to provide an objective presentation of all cancer centres (CCs) and to provide information services to these centres in the respective regions (communication between CCs and their partners, regional data collection...). The individual CCs can use the portal to present their targets, the housed equipment and the quality of provided health care.
- Educational content: distribution of cancer burden and cancer care, lessons on cancer prevention, risk factors, diagnostics and therapy; focused both to lay public and to medical professionals.

The national web portal focused on the epidemiology of malignant tumours (www.svod.cz) and its educational analytic software^[13]:

- The web portal graphically presents more than 1.6 million records from the Czech National Cancer Registry. The portal is primarily focused on epidemiological data and the related time trends, inclusive of the regional differences and population risks. Users can find here a number of interactive tools and automatic reporting systems, facilitating orientation in the complex database even for the lay users, who can assimilate the analyses and outputs according to their own preferences. The portal also ana-

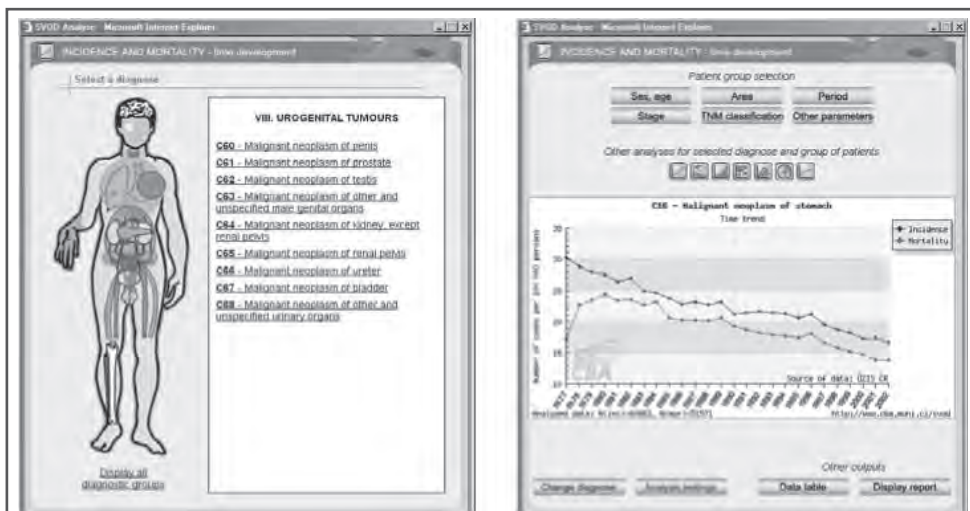


Figure 1. E-learning tools of the Czech population cancer registries – main workplace of the user/student. The tool integrates selection of diagnosis and other epidemiological characteristics.

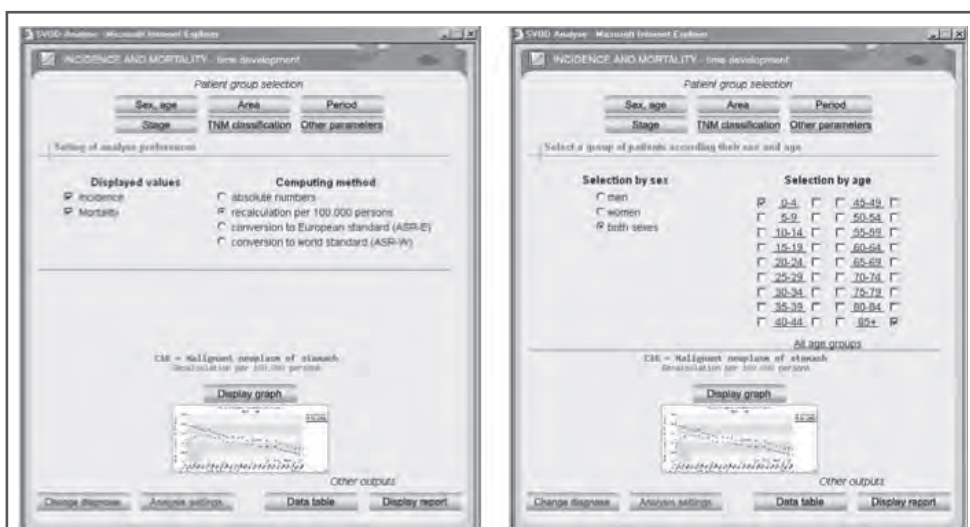


Figure 2. E-learning tools of the Czech population cancer registries – examples of interactive analysis setting: selection of requested epidemiologic parameter, setting of appropriate units (absolute numbers, crude rate and age standardized ratio – European or World standard), definition of target group of patients, clinical stage, TNM classification and other parameters related to the status of the patient.

lyzes the demographic data of the Czech population (this function has been made available thanks to the cooperation with the Czech Statistical Office).

- Educational content (examples in figures 1–4): interactive tools which enable user to analyse cancer burden in the Czech Republic according to diagnoses, diagnostic parameters and therapeutic

outcomes; cancer epidemiology on-line supported with e-tutorial of TMN classification of malignancies.

- *Incidence and mortality*: time trends of incidence, mortality and mortality/incidence ratio. Available parameters are absolute numbers of incident cases, crude rate (number of cases per 100,000 people in population) and

age standardized ratio (ASR – European or World standard).

- *Time trends*: changes of incidence and mortality in time. Available parameters are growth indices and between-years changes.
- *Regional overview*: comparison of incidence and mortality in regions of the Czech Republic. Available parameters are crude rate and age standardized ratio (ASR – European or World standard), output could be bar-plot or map.
- *Age-adjusted analyses*: age structure of population of patients with selected diagnosis. Available parameters are absolute numbers of cases in age categories, % of cases in age categories and age adjusted rate.
- *Clinical stages*: time trends in proportion of patients diagnosed in specified clinical stage. Available parameters are absolute numbers, % and crude rate of patients in specified clinical stage(s).
- *International data*: comparison of incidence and mortality in the Czech Republic (CZ) with other countries. The analyses are based on data obtained from IARC database GLOBOCAN^[14, 15].
- *Comparative standards*: time trend of incidence or mortality in selected region in comparison with situation in the Czech Republic.
- *Typology of patients*: comprehensive overview of group of patient with specified diagnosis.

Web portals of the national cancer screening programmes (www.mamo.cz; www.kolorektum.cz; www.cervix.cz):

- These web portals deal with organized population screening programmes in the Czech Republic. Apart from organizational and educational materials, detailed reports on data audits and their

results are regularly published on these websites.

- Educational content: authorized tutorials of the screening procedures and examinations, including organization of the programme in the regions of the Czech Republic, cancer prevention and diagnostics; focused both to lay public and to medical professionals.

A specialized educational portal and e-learning analytical tools oriented on urological malignancies (www.uroweb.cz):

- The tool is focused on the assessment of the epidemiology, diagnostics, therapy and its results in urological malignancies in the Czech Republic. All population-based data from this domain is made available in an interactive manner, and reference survival rates are also provided. The project is the outcome of the cooperation between the Czech Society for Oncology and the Czech Urological Society.
- Educational content: both static and interactive learning materials and tools, interactive sections enable teachers or students to analyse all accessible data from this field of cancer care, including international benchmarking of epidemiologic characteristics (see also Figures 1–4).

Methodical background for clinical and drug registries (www.registry.cz):

- This methodical portal provides the background and maintenance data for the drug and clinical registries in the Czech Republic. The portal informs both the professionals and lay persons about the development of methods for registering clinical data, and describes the standards for on-line information systems and on-line available registries. This platform also led to the establishment of numerous drug registries which are focused on anticancer pharmacotherapy (for instance, sub-portals of

respective projects such as <http://herceptin.registry.cz>, <http://tarceva.registry.cz>, <http://avastin.registry.cz>, see Table 1), or on the assessment of data collected within individual hospitals or data describing selected diagnostic groups of malignant tumours (such as <http://uranos.registry.cz>, <http://hardrock.registry.cz>, <http://pons.registry.cz>).

- Educational content: electronic records of cancer patient accessible for education, reporting enabling practical demonstration of health technology assessment methodology, clinical data accessible for education of modern targeted therapy of malignancies and principles of personalized medicine.

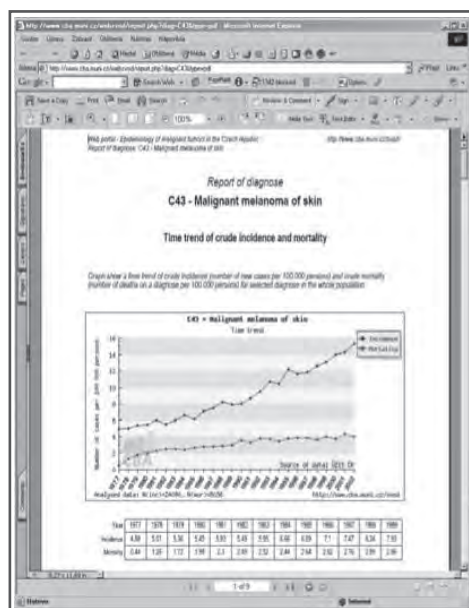


Figure 3. E-learning tools of the Czech population cancer registries – example of comprehensive educational report, incidence and mortality in trend, commented.

The set of educational tools focused on standardization of anti-tumour chemotherapy (DIOS project – Dose Intensity as Oncology Standard, <http://dios.registry.cz>):

- This web portal deals with the parametric assessment and adherence to anticancer chemotherapy guidelines.

The portal provides analytical and software support for its users, as well as the realization of multicentre projects. The most valuable tools involve the Central Library of Chemotherapy Regimens, and a set of automated software tools, such as Therapy Organizer, Dose Intensity Calculator, and reporting tools. The portal contributes to the standardization of diagnostic and therapeutic procedures.

- Educational content: electronic library of CHT regimens with tools for tutors, analytic tools allowing evaluation of cancer care standards^[16]:
 - Search engine allows searching for any regimen. Searching is available using the basic criteria like cancer diagnoses (according to the ICD-10), the applied drugs as part of the regimen, the treatment purpose (adjuvant, neoadjuvant and palliative), and the line of treatment.
 - Therapy organizer launches an application that projects the scheme of selected regimen into a real calendar and suggests scheduling of the treatment for a given patient. It offers both planning of the start dates of single cycles, as well as the calculation of absolute doses of cytostatics, according to the regimen-specific conversion unit (body surface area, weight, glomerular filtration rate).
 - Dose intensity calculator launches an application which calculates the standard and really achieved dose intensity. The application also supports various simulations for educational purposes. The input data involves the number of cycles, the actual start dates and also some data on the patients, which is necessary for calculating the absolute doses of anticancer drugs. The application automatically computes the absolute dose intensity for standard dose and the actual applied dose. By comparing these values, relative DI is calculated as percentage. The decline

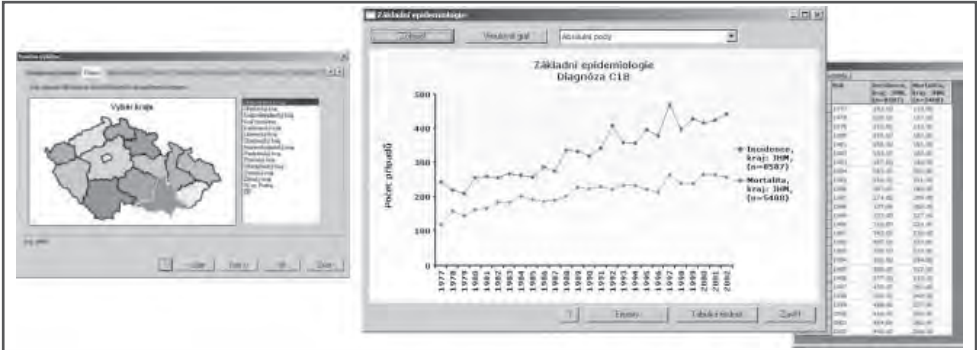


Figure 4. E-learning tools of the Czech population cancer registries – example of analytic window related to geographic information systems, a tool for teaching of disease mapping techniques.

Table 1. Selected Czech clinical registries focused on targeted cancer therapy.

Registry / project and its description	No. of records available	Reached follow-up time
Avastin http://avastin.registry.cz Clinical registry of patients with advanced colorectal carcinoma, breast carcinoma or lung carcinoma treated with Avastin.	2,420	10 (3–30)
Erbixut http://erbitux.registry.cz Clinical registry monitoring the treatment of Erbixut, a targeted therapy used in colorectal cancer and locally advanced head and neck cancer.	650	9 (2–30)
GIST http://gist.registry.cz Clinical registry for the collection of epidemiological and clinical data on patients with gastrointestinal stromal tumours (GIST).	400	28 (3–53)
Herceptin http://herceptin.registry.cz Clinical registry of HER2/Neu positive breast cancer patients treated with Herceptin.	2,100	16 (3–43)
Lapatinib http://lapatinib.registry.cz International clinical registry of ErbB2-positive breast cancer patients treated with Lapatinib.	100	7 (2–25)
RenIS http://renis.registry.cz Clinical project for the collection of data on patients with malignant neoplasm of the kidney.	1,026	8 (2–25)
Tarceva http://tarceva.registry.cz Registry of patients with non-small cell lung carcinoma or pancreatic carcinoma treated with Tarceva.	1,412	6 (1–16)

- in DI under 90 and 60% is highlighted as warning signal. The calculator and organiser are closely interconnected and the user can conveniently switch between them.
- Febrile neutropenia monitor is aimed at EORTC guidelines as information support for the management of risks. Each CHT regimen is linked to meta-data describing the available infor-

mation on FN risk. The user enters the system through clinically relevant questionnaire that helps to estimate the proper risk level, subsequent simulation helps to optimise further therapy.

Discussion

E-learning in cancer care education in the Czech Republic

Oncology in various levels of specialization is taught at all seven Czech faculties of medicine (associated with three universities): both in the master and in the doctoral study programmes. All these programmes consume e-learning support which is created and guaranteed by teaching teams of individual faculties. Finalized educational materials can be shared in the network of all faculties, established as centralized platform of e-learning activities^[12]. This network, called MEFANET, covers also cancer care sections.

The lifelong learning is organized mainly by the Department of Medical Oncology at the Institute of Postgraduate Medical Education. This institution also provides support to applicants for certification in oncology as a clinical discipline. In recent years, the Czech Medical Chamber (CMC) has been increasingly involved in postgraduate education. CMC determines the number of credits to be attributed to doctors who have attended one-shot courses or other educational events within the continuing lifelong education. Here, the education based on e-materials generated from clinical practice can be implemented and utilized according to standards given by the European Association for Cancer Education. The e-learning support is guaranteed by the Czech Society for Oncology (CSO) which organizes scientific meetings on regular basis and several annual congresses with educational content.

All e-learning tools described in this section are continuously updated on the basis of real clinical data, provided mainly by

the Czech Comprehensive Cancer Centers (CCCs). These 13 centers has recently established closely collaborating network in which they share electronic standards for data collection. The collaborative environment in the CCCs network opens a space for many e-learning activities which are recommended in literature, for instance shared LMS modules, computer assisted simulations, educational internet portals accessible in intranet of hospitals or multimedia tools^[17, 18, 19].

In this paper we summarize complex e-learning tools operating over real clinical data. Implementation of these instruments closed the 1st phase of learning programme designed for the CCCs network. This strategy of course cannot replace traditional ways of teaching, particularly in undergraduate level. However, the organization scheme of Czech cancer care has been remarkably changed in recent years, which has influenced accessibility of care and distribution of patients. Current disparities in cancer care influence prevention and early diagnostics, as well as management of advanced cancers. That is why the e-learning based on processing of real clinical data was prioritized.

Added value of e-learning linked to the cancer care clinical practice

In its broad definition, e-learning includes a large spectrum of technologies and approaches that can be used in various areas of healthcare education. We should mention LMS courses, multimedia educational tools, interactive videos, interactive systems or voice response systems^[19]. Among these items, internet – based learning is increasingly accessible to a large spectrum of medical professionals, including GPs. The web-based technologies can address both narrow group of students in specific subject and the whole population of professionals. Many of the Czech national learning portals are also focused on patients and their relatives. In accordance with many published studies we regard educational support of

patients as very important component of the healthcare, stimulating their active participation in the therapy and compliance^[20, 21]. Patient educational level is associated with reachable therapeutic outcomes, including survival^[23].

E-learning tools which should be incorporated and used in clinical practice must work with the content generated by the practice itself. Educational content then comments and explains strong and weak points of care, emphasizes errors and benchmarks the measures which can be quantified. The authors are convinced that this type of e-learning can effectively support all levels of education. Furthermore, it offers easily acceptable feedback over clinical practice and its results and thus it aims at improvement in patient assessment, treatment and care. Although generally evaluated quality of the Czech cancer care can stand comparison with those in other developed countries, it has its weak points that can be improved by effective teaching. In this learning strategy, the clinical practice is learned by its own data and educational materials mature with improving clinical practice.

E-learning based on processing of real clinical data can provide also other distinct advantages which make it very effective. First, the content is generated in the routine operation of the clinical departments and thus it does not rely entirely on work invested by selected group of teachers. Second, learning of physicians and healthcare managers using their own data should be cost saving. Last but not least we should emphasize expectable effect on cancer care quality and results^[24]. Following fields belong to the most important topics which should be addressed by lifelong learning support:

- cancer burden monitoring and accessibility of cancer care to different social and demographic groups; disparities in cancer care;
- distribution of various types of cancer care in health care facilities, cancer management standards and HTA standards;

- cancer prevention with special focus on organized population cancer screening programmes;
- diagnostic and therapeutic standards in the way that corresponds to the principles of evidence – based health care research;
- controlling of cancer care quality and outcomes.

Among these topics, the cancer screening and cancer disparities were identified as the principal endpoints of the Czech educational strategy. These fields are also frequently addressed by e-learning activities abroad^[26, 27, 28]. Without efficient training and information support, involved health professionals use approaches which can inhibit positive trends. It strongly highlights the need for health professionals to be informed about the recent situation in cancer burden in their area, to recognize changing cancer care organization and to follow accessible technologies. E-learning represents effective pathway how to reach the desired progress in this field.

However, rapid progress in learning technologies meets serious limits in everyday clinical practice. Accessibility of relevant and complex data can be mentioned among most important problems. Although capacity of hospital information systems allows us to realize very demanding and time-consuming data transfers, standardization of common patient's documentation remains insufficient. The absence of standardized tools for electronic data capture in clinical practice limits further progress. Development of robust and efficient information infrastructure for prospective validation of standard clinical records is one of the most challenging priorities of healthcare informatics. Positive role of nationwide implementation of e-Health is expected in this field.

E-Health is defined by the World Health Organization as “the combined use of electronic communication and information technology in the health sector”^[25]. The first e-Health initiative of the Czech government

took place in 2007, when the Ministry of Health established a joint committee set up to work on the implementation of e-Health principles into the Czech healthcare system. In 2008, six goals which made up the national e-Health conception were formulated. The Czech Society for Oncology, as well as the leadership of most of the Czech cancer centers, has already initiated several developmental steps leading to the fulfillment of these strategic goals according to the following list:

- electronic medical record;
- electronic prescription;
- electronic identification and payments;
- registries and data consolidation;
- decision support systems, guidelines, clinical protocols;
- Health Technology Assessment;
- portals, education and telemedicine.

E-learning as support for interdisciplinary communication in cancer care

Changing structure of cancer centres and their regionally distributed satellite healthcare facilities increases importance of some new communication skills on the side of medical professionals. Hospitals must be able to mutually communicate and to share some parts of healthcare documentation; the interaction itself is realized in electronic form. We believe that projects which implement e-based communication tools directly in clinical practice strongly facilitate the desired communication habits. One way how to bridge the gap in communication between different medical disciplines involved in cancer care is to create clinical registries with some interdisciplinary educational content.

Communication among health care professionals is especially important in cancers which are commonly diagnosed in a certain type of regional healthcare facility and subsequently transferred to a cancer centre or another type of specialised hospital. The Czech professional medical societies

have initiated several projects that support a sort of “between-hospital” communication or professional sharing of at least partial patient’s documentation among physicians working in different medical specialties. This effort can strongly contribute to the standardisation of treatment processes including required early diagnostics of malignancies.

All these aspects can be related to cancer of urinary and genital system, for example. Using prostate cancer as a model, the currently ongoing project UJO (“Urology Joins Oncology”) serves as an example of the interdisciplinary electronically-based communication over parametric records of patients. The project is aimed at facilitating the collaboration between urologists and oncologists using modern ICTs. This non-interventional clinical registry is based on a fully parametric database equipped with an effective on-line system of data collection, centralised data management and electronic support of communication. Optimised dataset allows assessment of the risk and prognostic factors, as well as reference monitoring of the treatment outcomes. The project contributes to the implementation of electronic patient’s documentation in this field. Detailed information about the project is available at <http://ujo.registry.cz>. Although initiation of such type of project is very time consuming, the experience is very positive. The motivation to learn new skills that improve patient care comes from representative spectrum of clinical teams. Once motivated, trainees and practitioners alike require excellent content of the project database and based on the data, they modify approaches to improve outcomes.

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References

1. Boyle P, Ferlay J: Cancer incidence and mortality in Europe, 2004. *Ann Oncol* 2005; 16(3):481–488.
2. Curado MP, Edwards B, Shin HR, et al. (eds): *Cancer Incidence in Five Continents*, Vol. IX. IARC Scientific Publications No. 160, Lyon, IARC, 2007 [cited 2010 Sep 22]. Available from: <http://ci5.iarc.fr>
3. Ferlay J, Autier P, Boniol M, et al.: Estimates of the cancer incidence and mortality in Europe in 2006. *Ann Oncol* 2007;18(3): 581–592.
4. Dušek L (ed): *Czech Cancer Care in Numbers, 2008–2009*. Praha, GRADA Publishing, 2009.
5. Ginsburg GS, McCarthy JJ: Personalized medicine: revolutionizing drug discovery and patient care. *Trends in Biotechnology* 19 (2001), pp. 491–496.
6. Allison M: Is personalized medicine finally arriving? *Nature Biotechnology* 26 (2008), pp. 509–517.
7. Willard HF, Angrist M, Ginsburg GS: Genomic medicine: genetic variation and its impact on the future of health care. *Philosophical Transactions of the Royal Society of London – Series B: Biological Sciences* 360 (2005), pp. 1543–1550.
8. Czech Statistical Office. Demographic data of the Czech Republic and Death Records Database of the Czech Republic [cited 2010 Aug 18]. Available from: <http://www.czso.cz/eng/redakce.nsf/i/population>
9. Czech Statistical Office. Demographic Yearbook of the Czech Republic 2007 [cited 2010 Aug 18]. Available from: <http://www.czso.cz>
10. World Health Organization. International statistical classification of diseases and related health problems, 10th revision (ICD-10). World Health Organization, Geneva, 1992.
11. Institute of Health Information and Statistics of the Czech Republic (IHIS). National Health Information System (NHIS), Czech National Cancer Registry [cited 2007 Dec 20]. Available from: http://www.uzis.cz/info.php?article=368&mnu_id=7300
12. Schwarz D, Dušek L, 2008: A uniform platform for electronic publishing and sharing the educational content in the network of medical faculties MEFANET [online]. (Apr 2009) <http://portal.mefanet.cz>. Version 1.5.
13. Dušek L, Mužík J, Kubásek M, Koptíková J, Žaloudík J, Vyzula R: Epidemiology of tumours in the Czech Republic [online]. Masaryk University, [2007], [cit. 2008-8-26]. Available at: <http://www.svod.cz>. Verze 7.0 [2007], ISSN 1802-8861.
14. Ferlay J, Bray F, Pisani P, Parkin DM: *GLOBOCAN 2002: Cancer Incidence, Mortality and Prevalence Worldwide*. IARC CancerBase No. 5. version 2.0, Lyon, IARC, 2004 [cited 2010 Sep 22]. Available from: <http://globocan.iarc.fr>

15. Ferlay J, Shin HR, Bray F et al.: GLOBOCAN 2008: Cancer Incidence and Mortality Worldwide. IARC CancerBase No. 10, Lyon, IARC, 2010 [cited 2010 Sep 22]. Available from: <http://globocan.iarc.fr>
16. Klimeš D, Kubásek M, Šmíd R, Dušek L: Internet-based system for anti-tumor chemotherapy evaluation, *Comput. Methods Programs Biomed*, 93, 292–296 (2008).
17. Ziv A, Wolpe PR, Small SD, Glick S: Simulation-based Medical Education: An Ethical Imperative. *Simulation in Healthcare*, 1, 252–256, 2006.
18. Cook DA, McDonald FS: E-learning: Is there anything special about the “E”? *Perspect Biol Med* 51 (2008), p. 5.
19. Health e-Technologies Initiative, 2008: Using eHealth Interventions to engage consumers: A Practical Guide. Retrieved January 15th from: <http://www.hetinitiative.org>.
20. Agre P, Dougherty J, Pirone J: Creating a CD-ROM program for cancer-related patient education, *Oncol Nurs Forum* 29 (2002), p. 573
21. Sturdee DW: The importance of patient education in improving compliance, *Climacteric* 3 (Suppl 2) (2000), p. 9.
22. Meade CD, McKinney WP, Barnas GP: Educating patients with limited literacy skills: The effectiveness of printed and videotaped materials about colon cancer, *Am J Public Health* 84 (1994), p. 119.
23. Goodwin JS, Samet JM, Hunt WC: Determinants of survival in older cancer patients, *J Natl Cancer Inst* 88 (1996), p. 1031.
24. Nelson EA: E-learning A Practical Solution for Training and Tracking in patient-care Settings. *Nursing Administration Quarterly*, (27), 1, 29–32, 2003.
25. World Health Organization. Regional Office of the Mediterranean, 2005: E-Health in the Eastern Mediterranean. Retrieved January 15, 2009 from: <http://www.emro.who.int/HIS/ehealth/AboutEhealth.htm>
26. HRSA Health Disparities Collaborative, 2005: Cancer Screening and Follow-up. Retrieved May 14, 2009 from <http://www.ncchca.org/files/Clinical>.
27. Geller BM, Skelly JM, Dorwaldt AL, et al.: Increasing patient/physician communications about colorectal cancer screening in rural primary care practices, *Med Care* 46 (2008), p. S36.
28. Molenaar S, Sprangers MA, Rutgers EJ, et al.: Decision support for patients with early-stage breast cancer: Effects of an interactive breast cancer CDROM on treatment decision, satisfaction, and quality of life, *J Clin Oncol* 19 (2001), p. 1676.

THE EDUCATIONAL CONTENT OF THE CZECH SOCIETY FOR ONCOLOGY PORTAL (WWW.LINKOS.CZ)

03

Nováková P.

The Czech Society for Oncology (CzMA JEP)

Abstract

The official website for the Czech Society for Oncology (CzMA JEP) was established in 1999. In 10 years, a simple website containing basic information about the company developed into a portal which presents an overview of projects and activities in oncology throughout the Czech Republic and also contains the original sources and databases for education. The site is designed not only for the professional public but in an extensive specialized section also for people diagnosed with a tumor, their families and their friends. The site is regularly updated with new information. The part for patients was recognized as a continuing online source and was assigned ISSN 1801-9951. The site receives over 30,000 visitors every month.

The largest and the most visited part of the portal for experts is “Lifelong learning”, a section that has become the crossroads for professional users for information “about” and “for” education. It contains an original and often unique range of content and information resources for education, such as the Oncology database of domestic abstracts and the upcoming Czech-language educational texts of the ASCO (American Society of Clinical Oncology) with local commentary.

Given the fact that a reduction of mortality due to cancer is improved also by public awareness, general knowledge of preventive programs and timely medical examinations, CSO CzMA JEP puts emphasis on the education of ill and healthy people. In order to educate the lay public the experts on the single diagnoses prepare the original texts and select the references to the information resources for prevention and therapy related to oncological diseases. The educational content for the general public involved 70 experts. Information on the portal is connected with all the projects aimed at the general public.

Conclusion: The Portal of the Czech Society of Oncology is part of the rich spectrum of educational projects in the field of oncology, and it is one of the tools helping in the implementation of the National Cancer Control Program of the Czech Republic.

Keywords

The Czech Society for Oncology, Linkos, lifelong learning, databases, information resources for oncology, education cancer patients, information on disease, Czech National Cancer Control Program.

Introduction and purposes

The website of the Czech Society for Oncology belongs to a wide spectrum of informative and educational activities of the Czech Society for Oncology and its partners in the area of reducing the incidence and mortality

of oncological diseases in the Czech Republic. The strategy for fulfillment of this goal of the Czech National Cancer Control Program also includes the fight against cancer as a life-long interest of the lay and professional public. This strategy could not be

achieved by separated activities. Linkos.cz is therefore one of the tools of the professional society to present and implement the unified oncology information strategies towards experts, oncology patients, and the healthy population as well. In its educational concept, the aim of the portal is to show the experts and lay visitors the direction to information and projects which may be beneficial for their education and to offer the missing information resource databases in the oncology field as well.

Methods

To implement this strategy Linkos decided on an unlimited format that combines the oncological portal, which directs the visitors to all important projects and activities of the society on the Czech internet, with a profound website that provides original information sources, databases and materials for the education of experts and lay people with interactive items and tools which enable the visitors to influence the content of the web.

Linkos as the oncology education program with the original databases

Although Linkos is not a typical educational e-learning website and serves as the website of a professional society, its most extensive and visited part intended for professionals is the module called "Life-long learning". The basic pillar of the educational module is the extensive **calendar of professional educational events**, congresses, courses and seminars which provide the information for planning as well as the post-congress professional information, **a set of databases of secondary and primary information** with oncology topics, and **the guidepost** to the educational projects and activities of The Czech Society for Oncology and its partners. The most up-to-date of these projects are presented in this forum.

The databases containing secondary information with educational content direct the physicians, oncology nurses and other

health-care professionals not only to the full versions of the information resources – such as the oncology magazines, books, actual results of the randomized studies and the full texts of the recommended therapeutic procedures – but also to the medical portals, databases, oncology preventive programs and projects which evaluate the results and quality of medical care.

The full text **“The basic principles of the cytostatic therapy of cancer disease”** is a substantial educational tool for professionals as are the databases of the proposed treatment procedures of the main foreign professional societies and associations.

The Linkos website has hosted the **online version of the Clinical Oncology magazine** (e-ISSN 1802-5307) with a complete browsable full text archive since 1988.

Another primary educational tool which is developed, carried out and made available on the Linkos website is the **Database of local oncological abstracts**, which contains conference abstracts and presentations which were presented during educational events in the Czech Republic and which were professionally warranted by The Czech Society for Oncology. The database contains also the contributions presented by the Czech participants at the foreign congresses.

An activity prepared for the education of experts is the **Czech version of the educational texts of the ASCO** (American Society of Clinical Oncology) with the local comments of our leading experts, which will be intended for daily self-education and use in practice.

The Czech Society for Oncology sets as its aim to provide patients, their families and their friends with the maximum amount of information related to oncology diseases and to enable them to learn more about the diseases away from the stressful environment of the health-care establishment.

In the section for the education of patients and the lay public, which was recognized as a continuous on-line source and assigned the number e-ISSN 1801-9951, there can

Table 1. Summary of primary and secondary information resources with an educational purpose at www.linkos.cz.

Summary of databases for education at www.linkos.cz		
Database name	No. of records	Target audience
Calendar of oncological educational events	1,132	Professionals
Database of oncological magazines	210	Professionals
Online archive of the magazine Clinical Oncology	3,413	Professionals
Online version of the magazine Oncological Care	106	Professionals
Database of books with oncology topics	216	Professionals and lay people
Database of publications for patients and their relatives	97	Lay people
Database of local oncological abstracts	3,506	Professionals
Continuous information literature service	5,000	Professionals
Database of proposed therapeutic procedures	296	Professionals
Database of drugs (own interface for external data)	8,000	Professionals
Database of oncological drugs	130	Lay people
Oncology on the web	139	Professionals and lay people
Explanatory dictionary of oncology terms	822	Lay people
Psychological assistance topics	120	Lay people
Educational materials of ASCO with local comments	52	Professionals

be found mainly professionally guaranteed texts prepared for Linkos as well as information drawn from other CzMA activities, which form the information basis of the National Cancer Control Program of the Czech Republic. Patients will learn not only about the diagnosis and therapy of their disease but also have the current analysis of the incidence and mortality of the diagnosis available, which is prepared by the SVOD software leading to the web portal Epidemiology of Cancer in the Czech Republic, a summary of published books, the full texts of patient brochures related to the given issues, and a list of other websites and projects for patients on the given diagnosis related to oncological prevention and online consultations as well as the websites of foundations and professional departments. The educational texts are adapted for the need of lay people and contain comprehensible explanations of the medical terms, using references to the extensive oncological dictionary for patients which is prepared based on the visitors' needs.

The combination of the strong authorial background – which includes 70 experts on separate diagnoses, treatment methods and oncological care – together with extensive cooperation in the field of information and educational activities in oncology results in the success of the website of the Czech Society for Oncology, which helps to increase the oncology literacy of people in the Czech Republic.

Results

The selected format – a combination of a portal directing visitors to all the important projects and activities of the professional association on the Czech internet with a profound website providing databases of the primary and secondary information and original materials for the education of the experts and lay people with interactive items and tools to provide the visitors with the chance to influence the website's content – fulfills its role. This is evidenced by a continual growth in visitation of the portal, which has increased by

9,000 percent since the introduction of this strategy in 2004, and by the 5th place ranking among 1,180 websites with health and medical topics monitored in the TOP chart of Navrcholu.cz in 2008.

Conclusions

The website www.linkos.cz of the Czech Society for Oncology is part of a rich and

well-considered spectrum of information and educational activities of the Czech Society for Oncology (CzMA JEP) and its partners. It provides experts with an orientation in the educational oncological resources and helps to increase the oncological literacy of the Czech inhabitants, and hence helps to fulfill the Czech National Cancer Control Program.

References

1. Nováková P., Svoboda M., "Stránky České onkologické společnosti ČLS J.E.P. www.linkos.cz", XXIX. Brněnské onkologické dny a XIX. Konference pro sestry a laboranty, Ab. 6, 2005. Available: http://www.linkos.cz/odbornici/kongresy/abstrakta_vypis.php?ID=450
1. Nováková P., "Internetové stránky České onkologické společnosti ČLS JEP www.linkos.cz. Zpráva o návštěvnosti v roce 2008.", Available : http://www.linkos.cz/odbornici/org_info/Linkos2008_vybor02_2009.pdf

WEB SIMULATOR CREATION TECHNOLOGY

Kofránek J., Mateják M., Privitzer P.

*Laboratory of Biocybernetics, Dept. of Pathophysiology, 1st Faculty of Medicine,
Charles University, Prague*

04

Abstract

This document includes description of technologies that we use for the creation of web-based tutorials, educational and teaching simulators. When creating a web simulator, two types of problems must be taken into consideration. The first problem is the creation and identification of the mathematical model. This work is more of a research than development work, based on the creation of formalized mathematical description of the modeled reality. For the creation, tweaking/debugging and verification of simulation models, special software development tools are used. For a long time we have mostly been using Matlab/Simulink models, made by Mathworks, for the development process. Simulink belongs to block-oriented simulation languages, which enables the user to assemble computer models from each block with defined inputs and outputs, interconnect these blocks into computer networks and group computer networks into blocks with higher hierarchy. From the description of the block-oriented structure it is clear, how the values of each variable parameter is calculated in the model, that is, what is the algorithm for the relevant calculation process. Recently, we have been using a simulation environment based on the Modelica language. The most important innovation in Modelica is the option to describe each part of the model as a set of quotations and not as an algorithm used to solve these quotations. Models created in Modelica are well-arranged and better reflect the structure of the modeled reality. The other problem apparent during the creation of tutorial and educational simulators is the creation of the tutorial software itself. It is a very demanding development work, which requires the combination of ideas and experiences of teachers who create the script of the tutorial application, the creativity of art designers who create the multimedia components interconnected with the simulation model in the background, as well as the efforts of programmers who finally “sew up” the final masterpiece into its final shape. To automate the model debugging transfer from the simulation development environment (using Simulink or Modelica) into the development environment where the development application is programmed, specialized software tools (developed by us) are used. We have been creating tutorial simulators in ControlWeb development environments (originally designed for the creation of industrial control and measuring applications), in Microsoft .NET and Adobe Flash environments. Recently, we began using the Microsoft Silverlight platform, which enables distribution of simulators over the internet and may be executed directly into the internet browser environment (even on computers running various operating systems).

Keywords

Modeling, Simulation, Simulator

In place of an introduction – a web of physiological regulations

Thirty-six years ago the Annual Review of Physiology published an article (Guyton et al. 1972) which at a glance was entirely different from the usual physiological articles of that time. It was introduced by a large diagram on an insertion. Full of lines and interconnected elements, the drawing vaguely resembled an electrical wiring diagram at first sight (Fig. 1). However, instead of vacuum tubes or other electrical components, it showed interconnected computation blocks (multipliers, dividers, adders, integrators, functional blocks) that symbolized mathematical operations performed on physiological variables (Fig. 2). Bundles of connecting wires between the blocks indicated the complex feedback interconnection of physiological variables at first glance. The blocks were arranged in eighteen groups that represented individual interconnected physiological subsystems. In the centre was a subsystem representing circulatory dynamics – linked through feedback links with other blocks: From the kidneys to tissue fluids and electrolytes to autonomic nervous control and hormonal control including ADH, angiotensin and aldosterone (Fig. 3).

In this entirely new manner, using graphically represented mathematical symbols, the authors described the physiological regulations of the circulatory system and its broader physiological relations and links with the other subsystems in the body – the kidneys, volumetric and electrolyte balance control, etc. Instead of an extensive set of mathematical equations, the article used a graphical representation of mathematical relations. This syntax allowed depicting relations between individual physiological variables graphically in the form of interconnected blocks representing mathematical operations. The whole diagram thus featured a formalized description of physiological relations in the circulatory system

using a graphically represented mathematical model.

The actual description of the model in the article was mostly represented by the elementary (but fully illustrative) drawing. Comments on and reasons for the formulation of the mathematical relations were very brief, e.g.: “Blocks 266 through 270 calculate the effect of cell pO_2 , autonomic stimulation, and basic rate of oxygen consumption by the tissues on the actual rate of oxygen consumption by the tissues”. This required exceptional concentration (and certain physiological and mathematical knowledge) from the reader to be able to understand the formalized relations between physiological variables.

A monograph (Guyton et al. 1973) published a year later, in 1973, explained a number of the adopted approaches in greater detail.

We do not see a mathematical representation of reality very often in biology and medicine. It should be noted that the process of formalization, i.e. the translation of a purely verbal description of a given network of relations into the formalized language of mathematics, is delayed in biological and medical sciences in comparison with engineering sciences, physics or chemistry. While the process of formalization in physics started as early as the seventeenth century, in medical and biological sciences it has been relatively delayed due to the complicity and complexity of biological systems and has only advanced with cybernetics and computer technology. The methodological tool here is computer models built on a mathematical description of biological reality.

Formalized descriptions in physiology have been used since the late sixties (since the pioneering works of Grodins et al., 1967, describing respiration). Guyton's model was the first extensive mathematical description of the physiological functions of interconnected body subsystems and launched the field of physiological research that is sometimes described as “integrative physiology” today. Just as theoretical

physics tries to describe physical reality and explain the results of experimental research using formal means, “integrative physiology” strives to create a formalized description of the interconnection of physiological controls based on experimental results and explain their function in the development of various diseases.

From this point of view, Guyton’s model was a milestone, trying to adopt a systematic view of physiological controls to capture the dynamics of relations between the regulation of the circulation, kidneys, the respiration and the volume and ionic composition of body fluids by means of a graphically represented network.

Guyton’s graphical notation of a formalized description of physiological relations provides a very clear representation of mathematical correlations – the blocks in network nodes represent graphical symbols for individual mathematical operations and the wires represent individual variables. Guyton’s graphical notation was soon adopted by other authors – such as Ikeda et al. (1979) in Japan and Amosov et al. (1977) in the former USSR.

However, the graphical notation of the mathematical model using a network of interconnected blocks was only visualization when created – Guyton’s model and later modifications (as well as the models of other authors that adopted Guyton’s representative notation) were originally implemented in Fortran and later in C++.

Today’s situation is different.

Today, there are specialized software simulation environments available for the development, debugging and verification of simulation models, which allow creating a model in graphical form and then testing its behaviour. One of these is the Matlab/Simulink development environment by Mathworks, which allows building a simulation model gradually from individual components – types of software simulation elements that are interconnected using a computer mouse to form simulation networks. Simulink blocks are very similar to

the elements used by Guyton for the formalized representation of physiological relations. The only difference is in their graphical form (see Fig. 4).

This similarity inspired us to use Simulink to revive Guyton’s good, classic diagram and transform it into a working simulation model. When implementing the model in Simulink, we used switches that allow us to connect and disconnect individual subsystems and control loops while the model is running. We strove to keep the appearance of the Simulink model identical to the original graphic diagram – the arrangement, wire location, variable names and block numbers are the same.

The simulation visualization of the old diagram was not without difficulties – there are errors in the original graphic diagram of the model! It does not matter in the hand-drawn illustration but if we try to bring it to life in Simulink, the model as a whole collapses immediately. There weren’t too many errors – switched signs, a divider instead of a multiplier, mixed-up interconnections between blocks, a missing decimal point in a constant, etc. However, there were enough to prevent the model from working. Some of the errors could be seen at first sight (even with no knowledge of physiology) – it is obvious from the diagram that the value of some variables in some integrators would quickly grow to infinity in operation (because of incorrectly drawn feedback) and the model would collapse. With a knowledge of physiology and system analysis, however, all of the errors could be identified with some work (Fig. 5). A detailed description of the errors and their corrections is in Kofránek et al. 2007).

It is interesting that Guyton’s diagram as a complex drawing was reprinted many times in various publications (recently see e.g. Hall, 2004, Van Vliet and Montani, 2005). However, nobody mentioned the errors or made an effort to correct them. This was understandable at the time the diagram was created. Drawing software did not exist – the diagram was created as

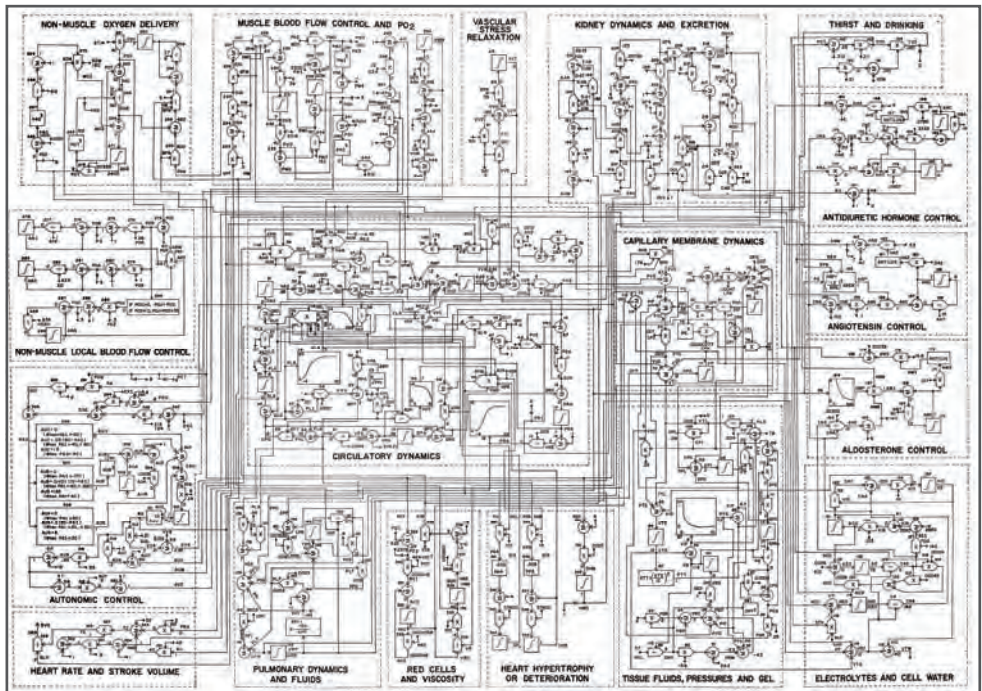


Figure 1. Guyton's blood circulation regulation diagram from 1972.

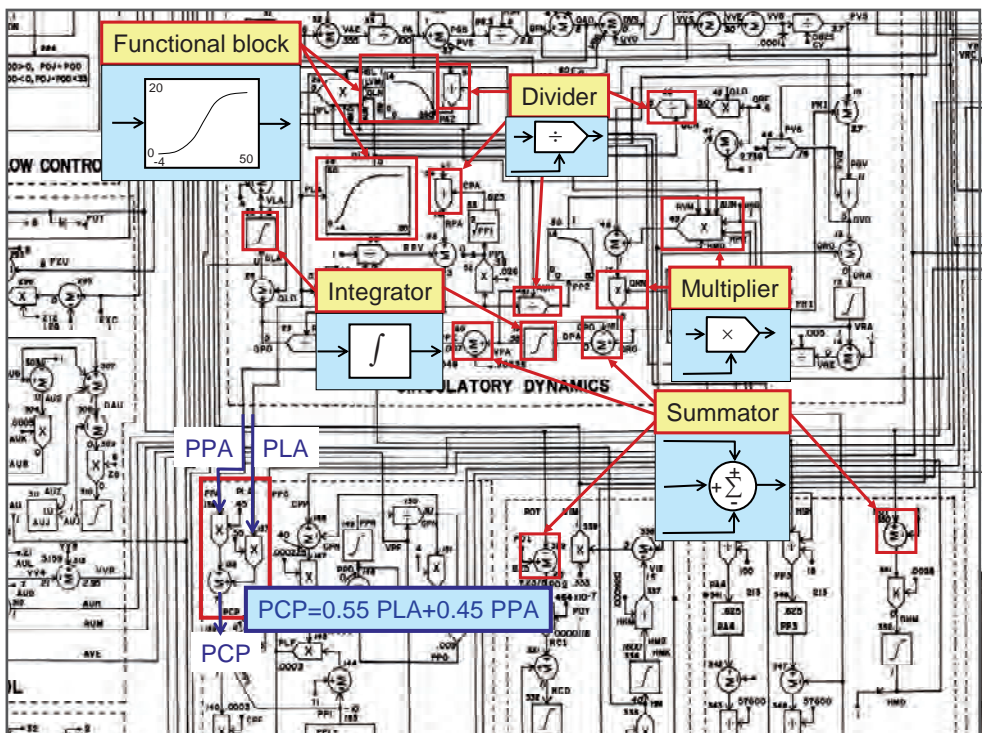


Figure 2. Individual elements in the block diagram of Guyton's model represent mathematical operations, the inter-connection of elements represents equations in a graphically expressed mathematical model.

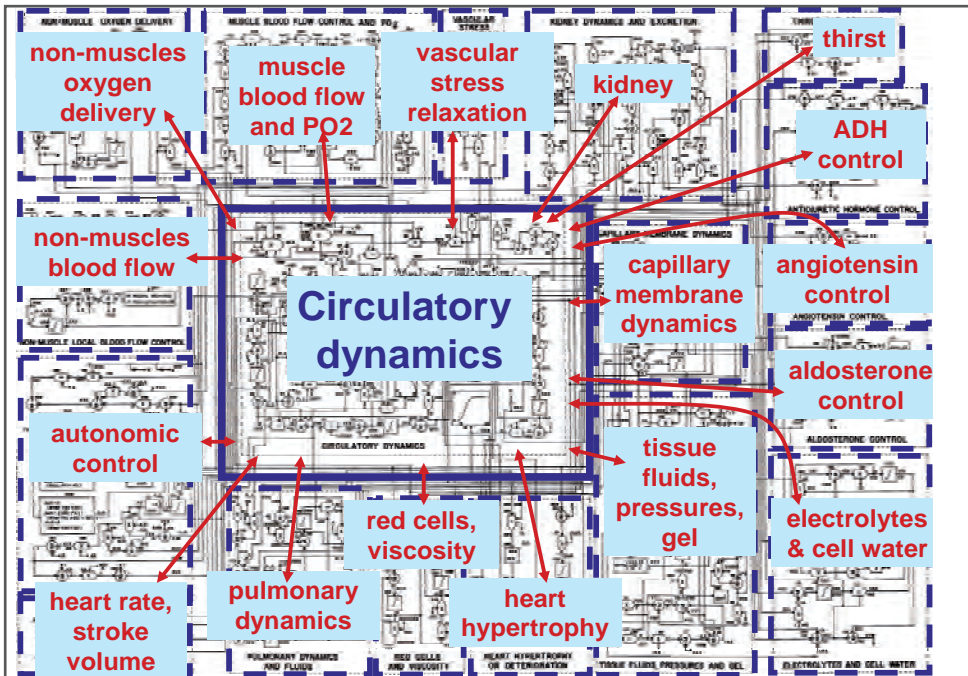


Figure 3. Individual interconnected subsystems in Guyton's model.

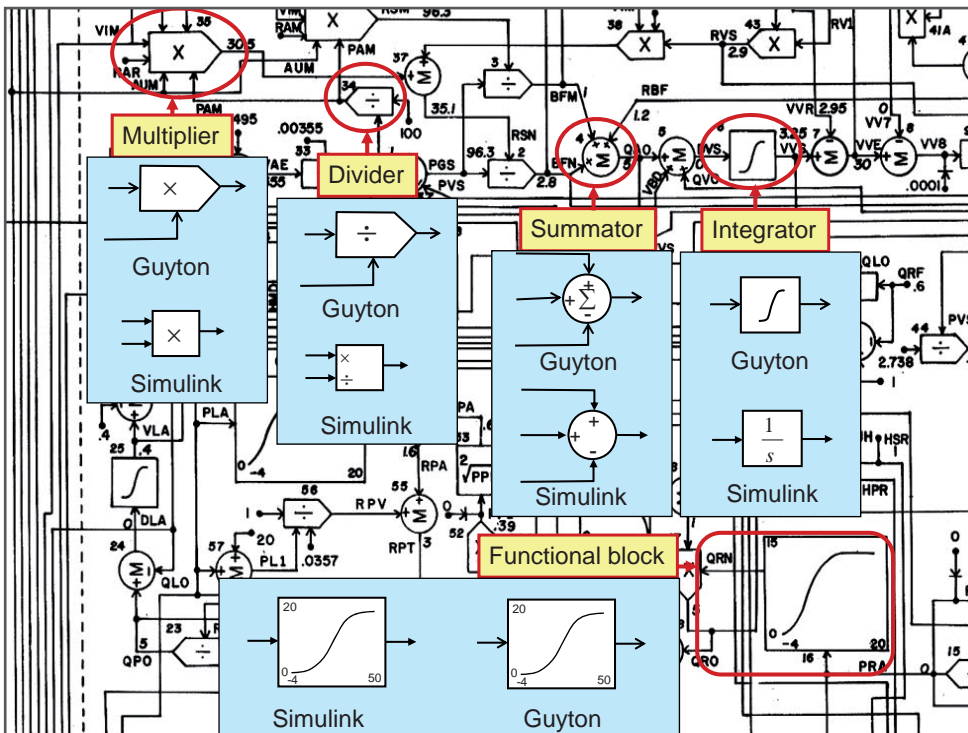


Figure 4. Appearance of blocks in Guyton's original graphical notation and in Simulink.

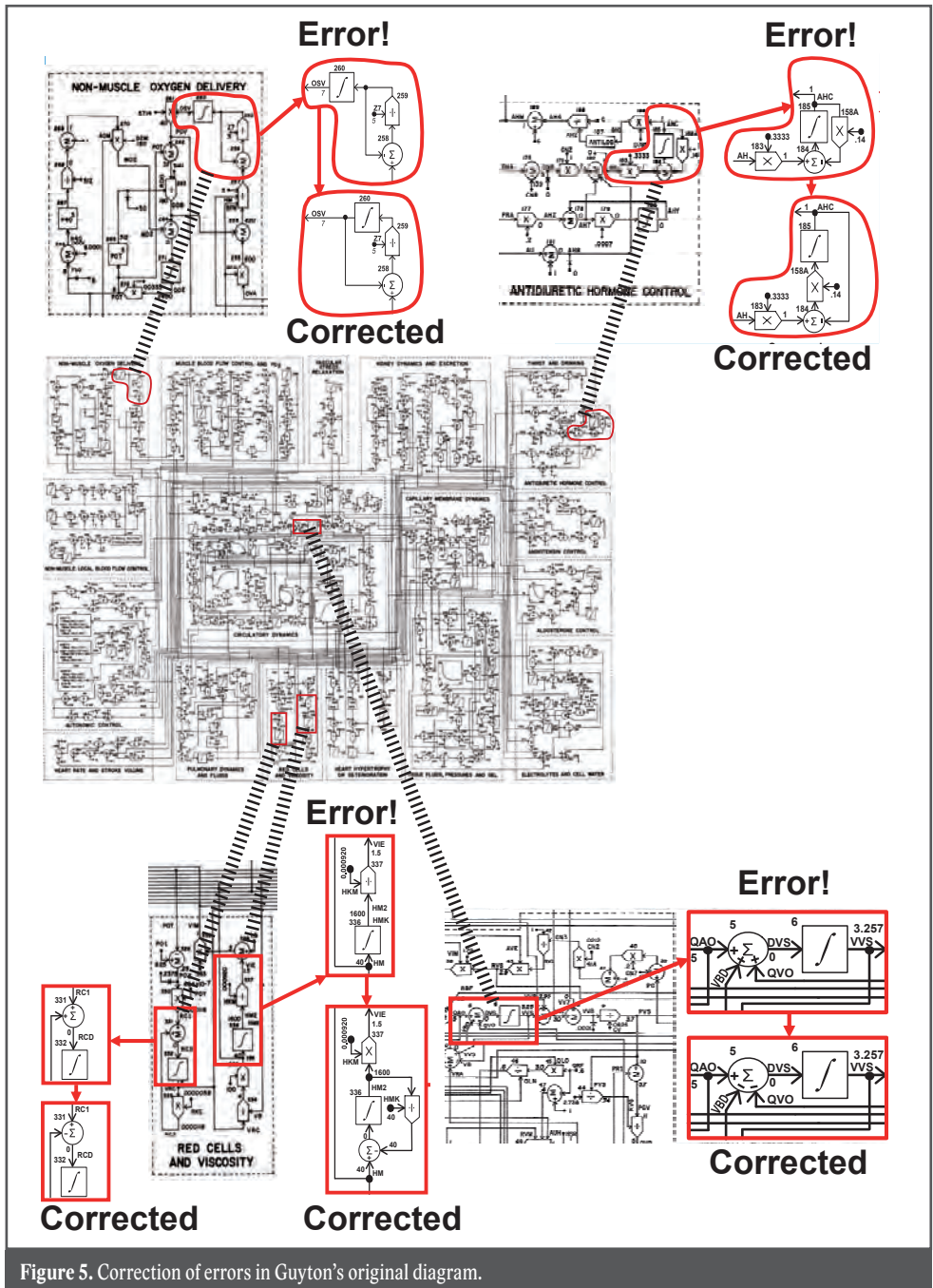


Figure 5. Correction of errors in Guyton's original diagram.

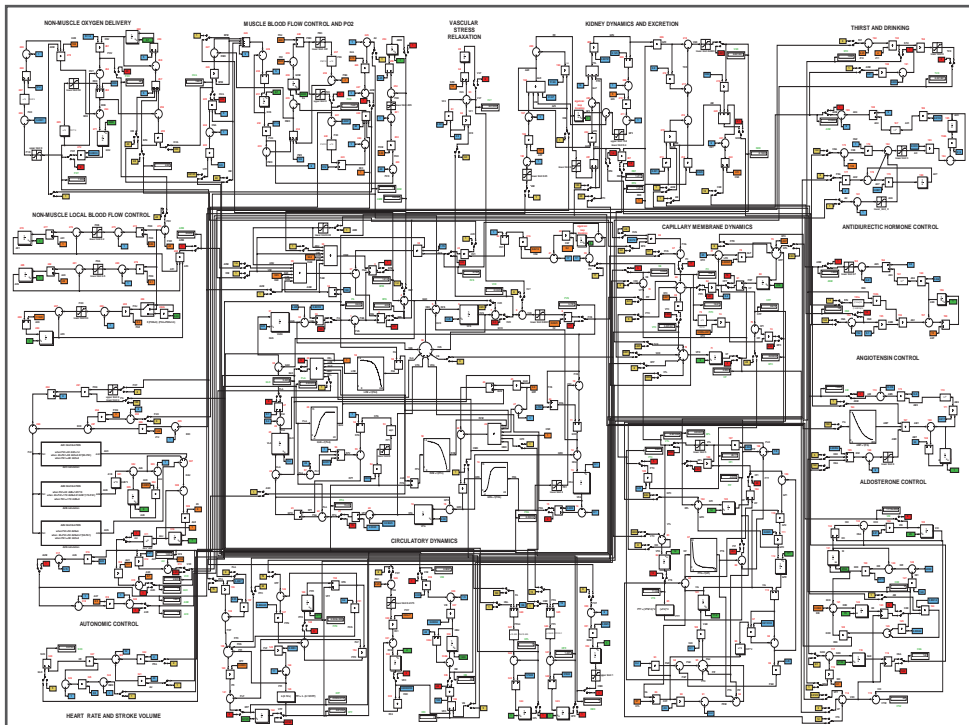


Figure 6. The implementation of Guyton's model in Simulink preserves the original arrangement of elements in Guyton's graphic diagram.

a complex drawing – and redrawing the complex diagram manually was not easy. It is also possible that the authors of the model did not wish to correct the errors – those who went to the trouble of analyzing the model could spot the drawing's “typos” and those who would just like to unthinkingly copy the diagram were out of luck. After all, the authors used to send out the source codes of Fortran programs for their model – so if anybody wished just to test the behaviour of the model, they did not have to program anything (at most, they had to routinely convert the program from Fortran to another programming language).

Our Simulink implementation of Guyton's (corrected) model (Figs. 6 and 7) is available for download at www.physiome.cz/guyton. Also available at that address is our Simulink implementation of a much more complex, later model from Guyton et al. There is also a very detailed description of all applied mathematical relations with an explanation.

Block-oriented simulation networks

Guyton's block diagram augured the rise of visual, block-oriented simulation languages. However, Guyton and his colleagues implemented the model in Fortran back in 1972 – Simulink version 1 was released eighteen years later (in 1990). Block-oriented simulation languages, of which Simulink is a typical example, allow assembling computer models from individual blocks with defined inputs and outputs. The blocks are grouped in libraries; when building a model, a computer mouse is used to create individual block instances, with inputs and outputs connected through wires that “conduct” information.

A Simulink network can be arranged hierarchically. Blocks can be grouped into sub-systems that communicate with their ambient environment through defined input and output “pins”, making “simulation chips” of a sort. A simulation chip hides the simula-

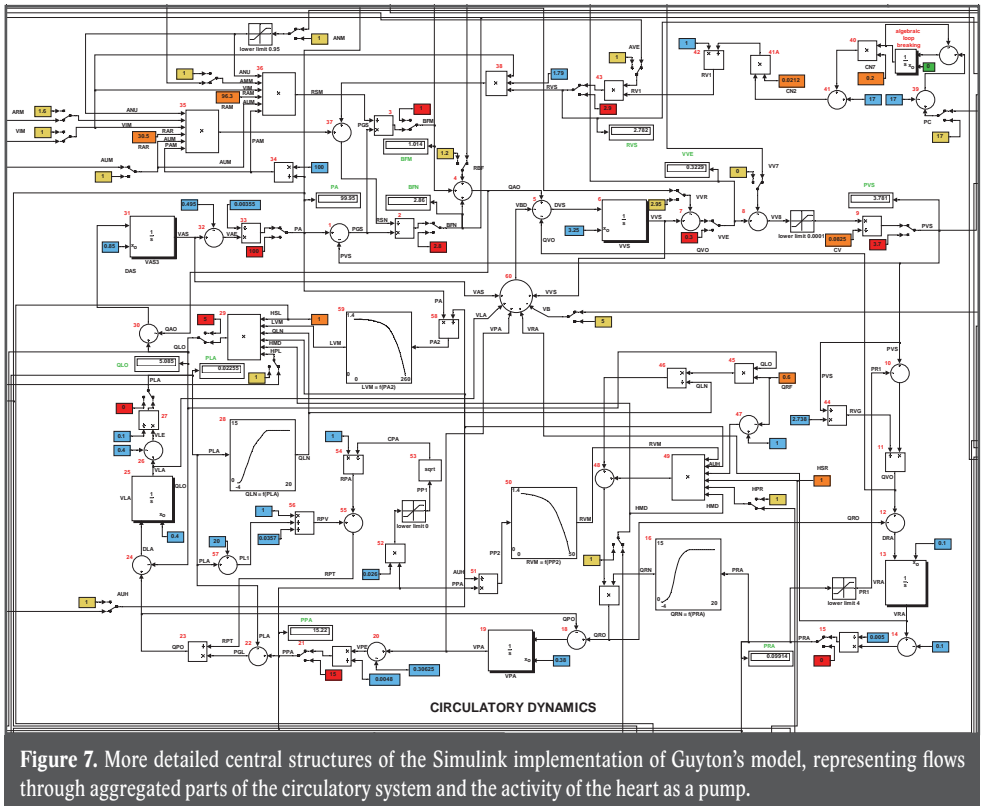


Figure 7. More detailed central structures of the Simulink implementation of Guyton's model, representing flows through aggregated parts of the circulatory system and the activity of the heart as a pump.

tion network structure from the user, much like an electronic chip hiding the interconnection of transistors and other electronic elements. Then the user can be concerned just with the behaviour of the chip and does not have to bother about the internal structure and calculation algorithm. The behaviour of a simulation chip can be tested by monitoring its outputs using virtual displays or virtual oscilloscopes connected to it. This is very useful especially for testing the behaviour of a model and expressing the mutual relations of variables.

The entire complex model can be then visualized as interconnected simulation chips and the structure of their interconnection clearly shows what effects are taken into account in the model, and how (Figs. 8–11). This is very useful for interdisciplinary collaboration – especially in borderline fields such as biomedical system modelling (Kofránek et al., 2002). An experimental physiologist does not have to examine the details of mathematical relations hidden “inside” a simulation chip; however, from the mutual

interconnection of simulation chips they will understand the model structure and will be able to check its behaviour in the appropriate simulation visualization environment.

Simulation chips can be stored in libraries and users can create their instances for use in their models (Fig. 12). For example, we created a Physiobrary for modelling physiological regulations (<http://www.physiome.cz/simchips>).

Hierarchical, block-oriented simulation tools are thus used advantageously in the description of the complex regulation systems that we have in physiology. A formalized description of physiological systems is the subject matter of PHYSIOME, an international project that is a successor to the GENOME project. The output of the GENOME project was a detailed description of the human genome; the goal of the PHYSIOME project is a formalized description of physiological functions. It uses computer models as its methodological tool (Bassingthwaighe, 2000; Hunter et al., 2002).

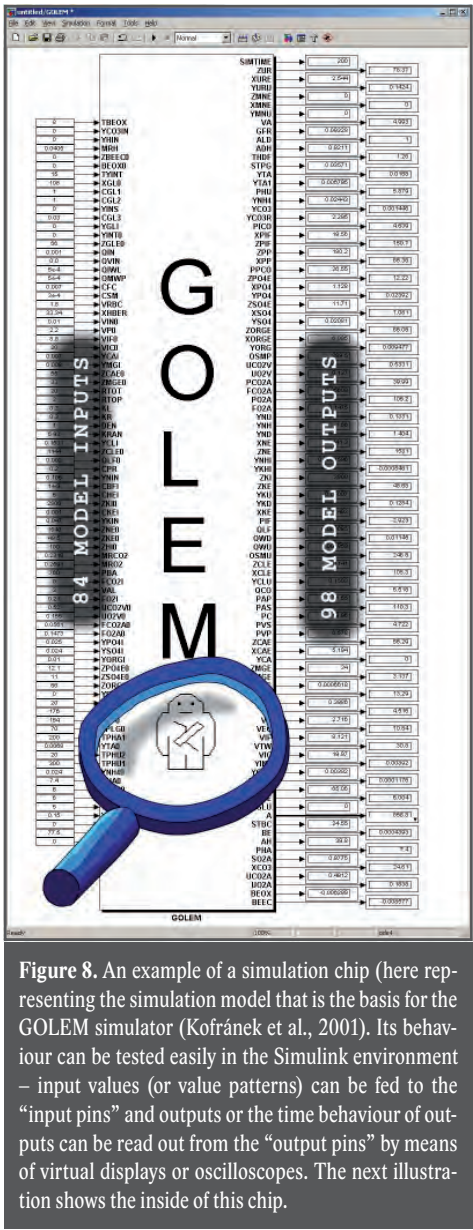


Figure 8. An example of a simulation chip (here representing the simulation model that is the basis for the Golem simulator (Kofránek et al., 2001). Its behaviour can be tested easily in the Simulink environment – input values (or value patterns) can be fed to the “input pins” and outputs or the time behaviour of outputs can be read out from the “output pins” by means of virtual displays or oscilloscopes. The next illustration shows the inside of this chip.

Several block-oriented simulation tools developed under the PHYSIOME project have been used as a reference database for a formalized description of the structure of complex physiological models. These include JSIM (<http://www.physiome.org/model/doku.php>) and CellML (<http://www.cellml.org/>). Prof. Guyton’s disciples and followers have expanded the original, extensive simulator of the circulatory system (Quantitative Circulatory Physiology (Abram et al. 2007) with an integrated

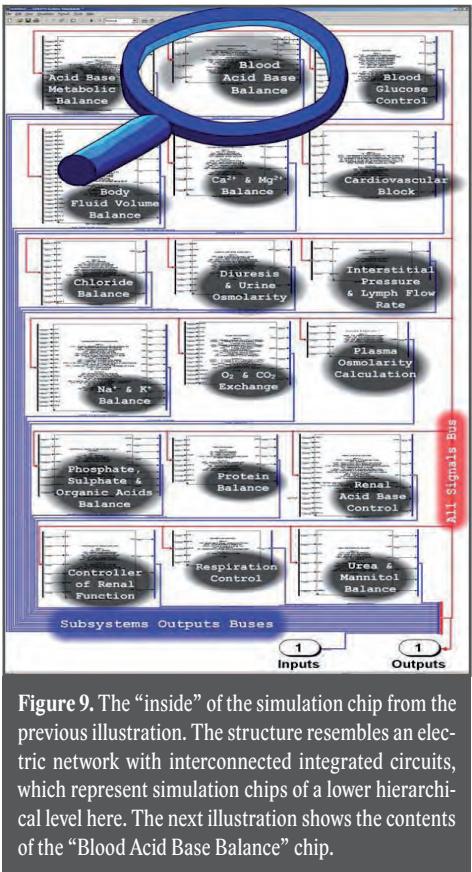


Figure 9. The “inside” of the simulation chip from the previous illustration. The structure resembles an electric network with interconnected integrated circuits, which represent simulation chips of a lower hierarchical level here. The next illustration shows the contents of the “Blood Acid Base Balance” chip.

connection of all important physiological systems. The latest result is the Quantitative Human Physiology simulator (Hester et al. 2008), now also distributed as “Digital Human”, which represents today’s most comprehensive and largest model of physiological functions. The model can be downloaded from <http://physiology.umn.edu/themodelingworkshop/>. The authors developed a special block-oriented simulation system to represent the complex model structure.

Causal and acausal approaches

Block-oriented tools work with hierarchically interconnected blocks. The connections between blocks “conduct” signals that transmit the values of individual variables from the output of a block to the inputs of other blocks. The blocks process input information into output information.

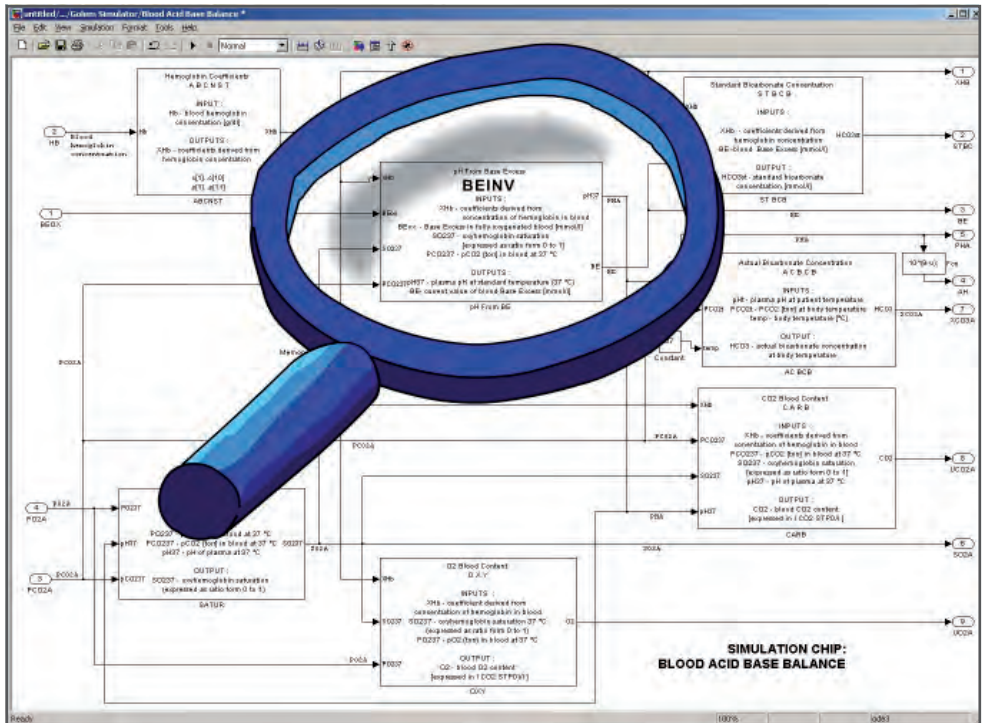


Figure 10. Simulation chips are arranged hierarchically. The illustration shows the “inside” of one of the simulation chips from Fig. 9. Since each simulation chip includes sufficiently detailed documentation of its inputs and outputs, the structure of relations inside a simulation chip (representing the physiological relations in a real organism) can be understood by physiologists. The next illustration shows the contents of the “BEINV” chip.

The hierarchically arranged block-oriented description clearly shows how the values of individual variables are calculated in the model – i.e. what the calculation algorithm is.

However, the interconnection of blocks in a network of relations cannot be completely arbitrary. Interconnected elements **may not include any algebraic loops** – i.e. cyclic structures where an input value fed to the input of a calculation block depends (through several intermediate blocks) on the block’s output value in the same time step.

For illustration, let us consider the small example of an algebraic loop in Simulink, a block-oriented language.

A model of the kidneys uses a simulation chip calculating the glomerular filtration rate. The individual inputs and outputs of that chip are shown in Fig. 13. The inside of the simulation chip consists in elementary blocks performing mathematical oper-

ations. The value of GFR, a variable representing the glomerular filtration rate, is calculated from the value of NETP; to calculate NETP it is necessary to know the value of PTP, which is however calculated as the quotient of GFR and TUBC (Fig. 14). Our Simulink diagram contains an algebraic loop that must be broken. Therefore we solve an implicit equation in the blocks identified as “Algebraic Constraint” in Fig. 15 to calculate GFR in each integration step. Therefore, a Simulink network does not constitute the graphical representation of mathematical relations in a model; rather, it is the graphical representation of a chain of transformations from input values to output values through Simulink elements where loops are not allowed.

If we focus on the representation of a structure of mathematical relations rather than the algorithm of calculations when building a model in Simulink, we can easily introduce algebraic loops into the model

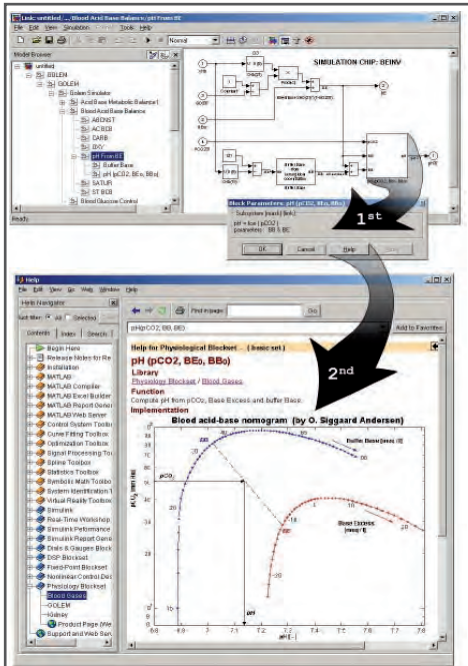


Figure 11. Structure of the BEINV simulation chip. Simulation chips at the lowest hierarchical level consist in interconnected elementary components of the Simulink development systems (adders, multipliers, integrators, etc.) and possibly simulation chips of further lower levels. These interconnected elements represent individual mathematical relations. Usually, each chip is dynamically linked with the appropriate documentation page including a factual description of the chip's function, including a description of the mathematical relations that constitute its basis.

(however, the compiler will warn us about this). There are methods that can be used to get rid of algebraic loops (e.g. see Dabney and Harman , 2004) – however, they lead to transformations that make the model structure even more complex and the model more difficult to understand. The need to have a fixed direction of connection from inputs to outputs with no algebraic loops also makes model building more difficult. The interconnection of blocks in Simulink thus *reflects the calculation procedure rather than the actual structure of the modelled reality*. We call this *causal modelling*. In complex systems, the *physical reality of the modelled system becomes somewhat lost under the structure of calculation* with this approach.

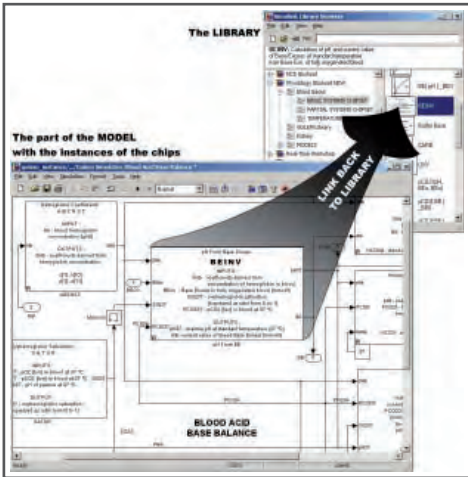


Figure 12. Simulation chips can be gathered in hierarchically arranged libraries in Simulink. It is then possible to use the mouse to “pick up” individual chips from the libraries (as from a tool palette), place them into the created application, interconnect them and create more complex models.

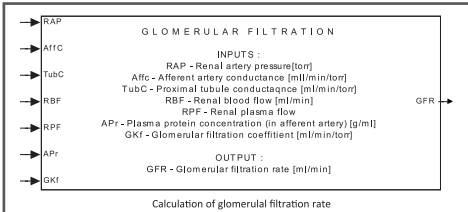


Figure 13. The “Glomerular Filtration” simulation chip calculates the glomerular filtration rate. The structure of calculation is hidden from the user. However, there must be no algebraic loops inside a chip.

New, “*acausal tools*” have recently been developed for the creation of simulation models. The major innovation brought about by acausal modelling tools is the possibility to describe the individual parts of a model directly *as a system of equations rather than an algorithm for solving the equations*. The notation of models is declarative (we describe the structure and mathematical relations, not the calculation algorithm) – thus the notation is acausal. Acausal modelling tools work with interconnected components that are instances of classes in which equations are directly defined. The components (i.e. instances of classes with equations) can be interconnected by

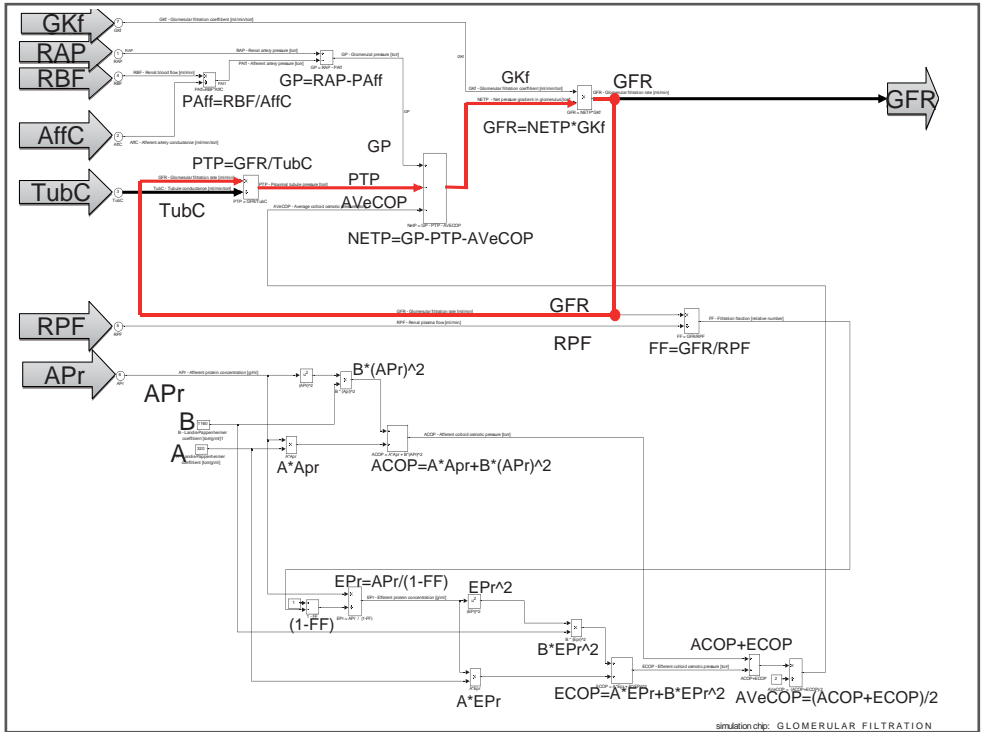


Figure 14. The interconnection of individual blocks inside the “Glomerular Filtration” simulation chip graphically represents individual mathematical relations for the calculation of the glomerular filtration rate. However, there is an algebraic loop. It is necessary to break the loop.

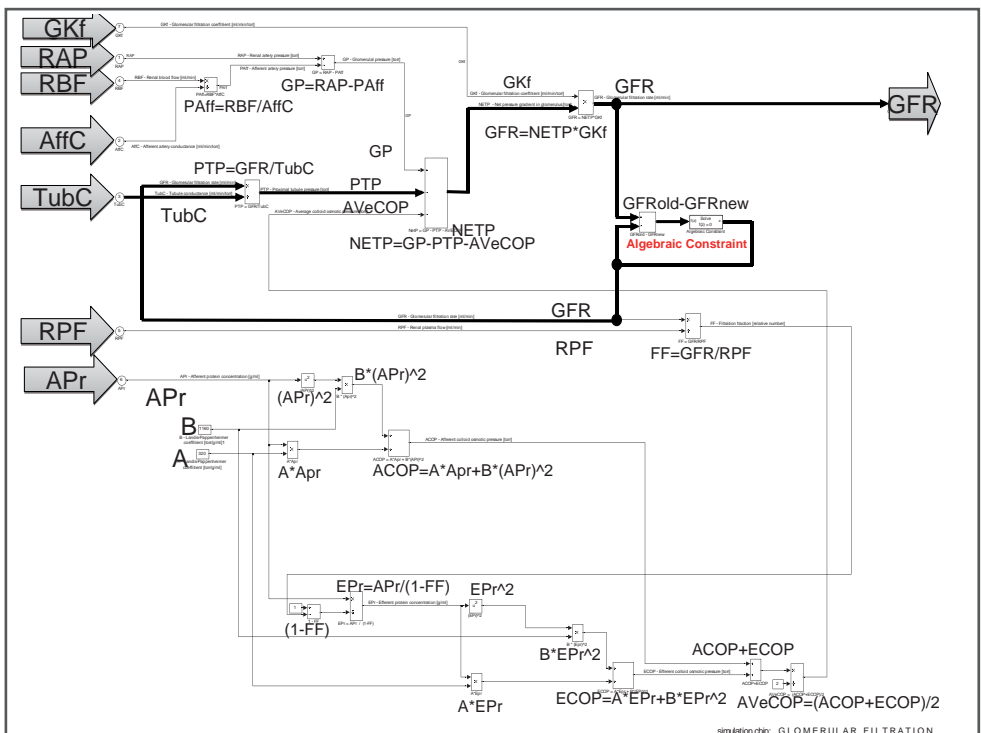


Figure 15. Breaking the algebraic loop in the calculation of the glomerular filtration rate. The interconnection of Simulink blocks reflects the calculation procedure rather than a graphical representation of mathematical relations.

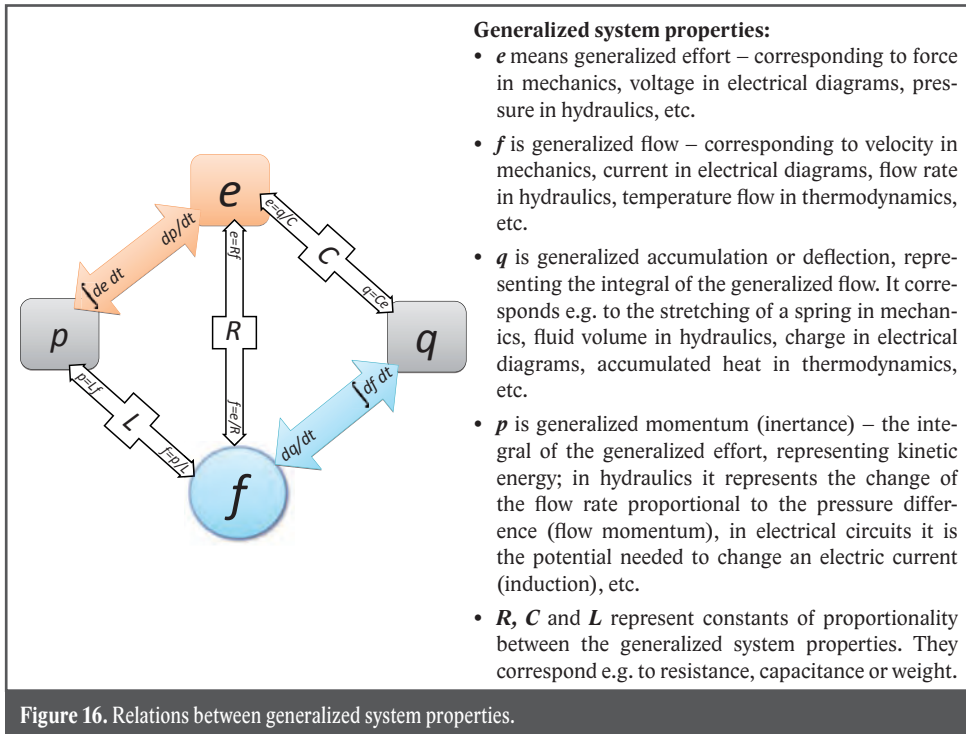


Figure 16. Relations between generalized system properties.

means of precisely defined interfaces – connectors; this defines a system of equations. The latest version of Simulink provides certain options for using acausal tools as well. Mathworks, the producer of the Matlab/Simulink simulation tools, responded to the new trends by creating a special acausal Simulink library – Simscape – and related domain libraries such as SimElectronics, SimHydraulics, SimMechanics, etc.

A modern simulation language that is built directly on the acausal notation of models is **Modelica** (Fritzson, 2003). It was originally developed in Sweden and is now available both in an open-source version (developed under the auspices of Modelica Association, <http://www.modelica.org/>) and in two commercial implementations.

The first commercial implementation is made by Dynasim AB – which has been bought by Dassault Systemes, a multinational corporation (sold under the name of **Dymola**, currently in version 7.1), and the other commercial implementation is made by MathCore (sold under the name of **MathModelica**). Dynasim's Modelica has a good connection to the Matlab and Simulink sim-

ulation tools, while MathModelica can connect to the Mathematica environment made by WoModelica works with interconnected components that are instances of individual classes. Unlike the implementation of classes in other object-oriented languages (such as *java C#* or *Java*), classes in Modelica have an additional special section in which **equations** are defined.

The equations do not mean assignment (i.e. storing the result of the calculation of an assigned command in a variable) but rather the definition of relations between variables (as is common in mathematics and physics). For example, the following notations of relations between variables expressing the resistance (R), flow (F) and pressure gradient (P) are equivalent:

$$F = P / R$$

$$P / R = F$$

$$P = R * F$$

$$R * F = P$$

$$R = P / F$$

$$P / F = R$$

Components (class instances) in Modelica can be interconnected by means of precisely defined interfaces – **connectors**.

What is important is that the interconnection of components actually *interconnects systems of equations in the individual components* with one another. *By interconnecting Modelica components, we do not define the calculation procedure but rather the modelled reality. The method of solving the equations is then “left to the machines”.*

Generalized system properties

The representation of a model in an acausal simulation environment resembles the physical reality of the modelled world more than the standard interconnected block diagrams in causal modelling tools. This is associated with the generalized system properties of the real world (Fig. 16), where an important role is played by *generalized effort* (corresponding to force, pressure, voltage, etc. in the real world) and *generalized flow* (corresponding to current, flow rate, etc. in the real world). The integral of generalized flow is *generalized accumulation or deflection* (in the real world, this can be e.g. an electrical charge but also the volume of a liquid

or gas, stretching of a spring, accumulated heat, etc.). The integral of generalized effort is generalized momentum (this represents flow momentum in hydraulics, induction in electrical circuits, etc.).

Also related to the generalized system properties is the fact that descriptions of models of biological or physiological processes often use electrical or hydraulic analogies for reasons of clarity.

Let us illustrate the utilization of generalized system properties and the difference between modelling in block-oriented simulation tools and in Modelica with a physiological reality modelling example – a model of simple pulmonary ventilation mechanics. Let us consider a *simple pulmonary mechanics model* that is schematically shown in Fig. 17. With a high level of simplification, the lungs can be seen as three bags interconnected through two tubes. The lungs are connected to the fan of the artificial pulmonary ventilation equipment, which periodically drives air into the lungs with the pressure **PAO**. **P0** is the pressure of the ambient atmosphere. Airflow **Q** runs through the upper respiratory tract that has the resist-

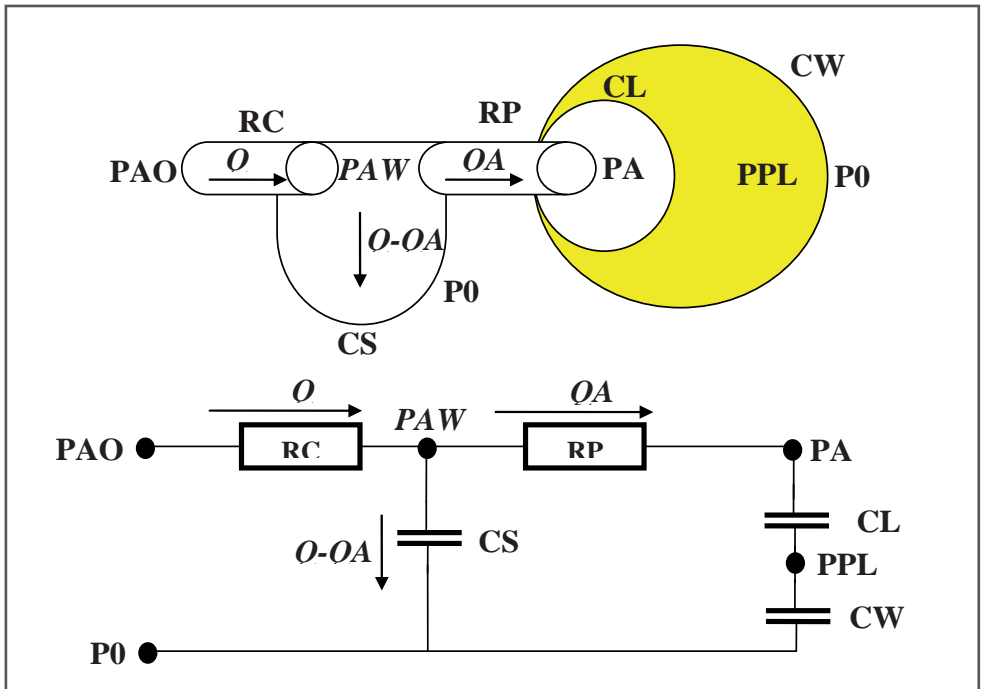


Figure 17. A simple pulmonary mechanics model (hydraulic and electrical analogy).

ance **RC**. From the upper respiratory tract, air forces its way through the lower respiratory tract to the alveoli. The resistance of the lower respiratory tract is **RP**, the pressure in the central parts of the respiratory tract (at the boundary between the upper and lower respiratory tracts) is **PAW**, the pressure in the alveoli is **PA**.

Air expands the pulmonary alveoli, whose compliance is **CL** (as the total compliance of the lungs). The interpleural cavity is in between the lungs and the rib cage. The pressure in it is **PPL**. The chest has to expand as well during artificial pulmonary ventilation when air is forced into the lungs – the chest compliance is **CW**. The small portion of air that does not reach the alveoli expands the respiratory tract instead – its compliance is **CS**.

Now we can set up our equations. According to Ohm's law, it must be true that:

$$\begin{aligned} PAW - PA &= RP QA \\ PAO - PAW &= RC Q \end{aligned} \quad (1)$$

The relation between the compliance, pressure gradient and volume (expressed as the integral of the flow rate) is expressed by these equations:

$$\begin{aligned} PA - PPL &= \frac{1}{CL} \int QA dt \\ PPL - P0 &= \frac{1}{CW} \int QA dt \\ PAW - P0 &= \frac{1}{CS} \int (Q - QA) dt \end{aligned} \quad (2)$$

According to the generalized Kirchhoff's law, the sum of all pressures (voltages) along a closed loop must be equal to zero, i.e. the following must hold true for the loop along the node PAW and along the node PAO:

$$\begin{aligned} (PAW - PA) + (PA - PPL) + \\ + (PPL - P0) + (P0 - PAW) &= 0 \end{aligned}$$

$$\begin{aligned} (PAO - PAW) + (PAW - P0) + \\ + (P0 - PAO) &= 0 \end{aligned} \quad (3)$$

Substituting from the equations for Ohm's law and compliances, we get:

$$\begin{cases} RP QA + \left(\frac{1}{CL} + \frac{1}{CW} \right) \int QA dt - \frac{1}{CS} \int (Q - QA) dt = 0 \\ Q RC + \frac{1}{CS} \int (Q - QA) dt + (P0 - PAO) = 0 \end{cases} \quad (4)$$

Causal approach – implementation of the pulmonary ventilation mechanics model in Simulink

When building a model in Simulink, we have to define precisely the *procedure of calculation* from input variables to output variables. If we wish to calculate the reaction of the air flow to/from the lungs (**Q**) to the input – i.e. to the changes in pressure at the beginning of the respiratory tract (**PAO**) caused by the artificial pulmonary ventilation apparatus – the Simulink model will look like Fig. 18.

We can also simplify the Simulink model. First we obtain a differential equation (input variable **PAO**, output **Q**) from equations (4):

$$\begin{aligned} \frac{d^2 PAO}{dt^2} + \frac{1}{RP CT} \frac{dPAO}{dt} &= RC \frac{d^2 Q}{dt^2} + \\ + \left(\frac{1}{CS} + \frac{RC}{RP CT} \right) \frac{dQ}{dt} + \\ + \frac{1}{RP CS} \left(\frac{1}{CL} + \frac{1}{CW} \right) Q \end{aligned} \quad (5)$$

When we enter the numeric parameters of resistance (in units cm H₂O/L/sec) and compliance (in units L/cmH₂O) (Khoo, 2000):

$$\begin{aligned} RC &= 1; \quad RP = 0,5; \quad CL = 0,2; \\ CW &= 0,2; \quad CS = 0,005 \end{aligned} \quad (6)$$

the equation (5) simplifies:

$$\begin{aligned} \frac{d^2 PAO}{dt^2} + 420 \frac{dPAO}{dt} = \frac{d^2 Q}{dt^2} + \\ + 620 \frac{dQ}{dt} + 4000 Q \end{aligned} \quad (7)$$

In the Laplace transform of the equation (7), we get:

$$\frac{Q(s)}{PAO(s)} = \frac{s^2 + 420s}{s^2 + 620s + 4000} \quad (8)$$

This allows simplifying the Simulink model (Fig. 19):

However, when the values of the parameters change, the transform function (6) must be recalculated and the Simulink model will change.

Now we will make the model a little more complex by taking *air inertia* in the upper respiratory tract into account (Fig. 20).

In addition, we will now take into account the inertial element $LC = 0.01 \text{ cm H}_2\text{O s}^2 \text{ L}^{S1}$:

$$LC = \frac{\Delta P}{\frac{dQ}{dt}} \quad (9)$$

where P is the pressure gradient and dQ/dt is the flow acceleration, or:

$$\Delta P = LC \frac{dQ}{dt} \quad (10)$$

Then we get this instead of the system of equations (4):

$$\begin{cases} RP \frac{dQA}{dt} + \left(\frac{1}{CL} + \frac{1}{CW} \right) QA - \frac{1}{CS} (Q - QA) = 0 \\ RC \frac{dQ}{dt} + LC \frac{d^2 Q}{dt^2} + \frac{1}{CS} (Q - QA) + \frac{dP0}{dt} - \frac{dPAO}{dt} = 0 \end{cases} \quad (11)$$

Instead of the equation (7), we get:

$$\begin{aligned} \frac{d^2 PAO}{dt^2} + 420 \frac{dPAO}{dt} = 0,01 \frac{d^3 Q}{dt^3} + \\ + 5,2 \frac{d^2 Q}{dt^2} + 620 \frac{dQ}{dt} + 4000 Q \end{aligned} \quad (12)$$

and in the Laplace transform, we get:

$$\frac{Q(s)}{PAO(s)} = \frac{s^2 + 420s}{0,01s^3 + 5,2s^2 + 620s + 4000} \quad (13)$$

This Simulink model will change (Fig. 21): Since we always have to take into account the direction of the calculation in Simulink, the actual Simulink diagram is rather dissimilar to the physical reality of the described system. Even a small change in the model, such as the inclusion of the inertial element, requires careful calculation and a change in the model structure. The model will change significantly even if we consider spontaneous breathing instead of artificial pulmonary ventilation. The model input will be not the pressure PAO generated by the artificial pulmonary ventilation respirator but e.g. the compliance of the thoracic wall CW (a cyclic variation in the compliance can be used to model the function of the respiratory muscles).

Acausal approach – implementation of the pulmonary ventilation mechanics model in Modelica

Comparing the model structure in Figures 17 and 20, formulated by means of generalized state variables, to the implementation of the model in Simulink (Figures 18, 19, 21), we can see that the interconnected blocks in Simulink express the structure of the calculation procedure rather than the structure of the modelled reality.

In Modelica, this is different.

Acausal modelling tools, of which Modelica is a typical example, work with interconnected components that are instances of special classes in which *equations* are defined. When modelling in Modelica, the first task is to formally express the modelled reality by means of equations.

In our simple pulmonary mechanics model, we describe the resistances of the respiratory tract, expansible elastic bags, and we

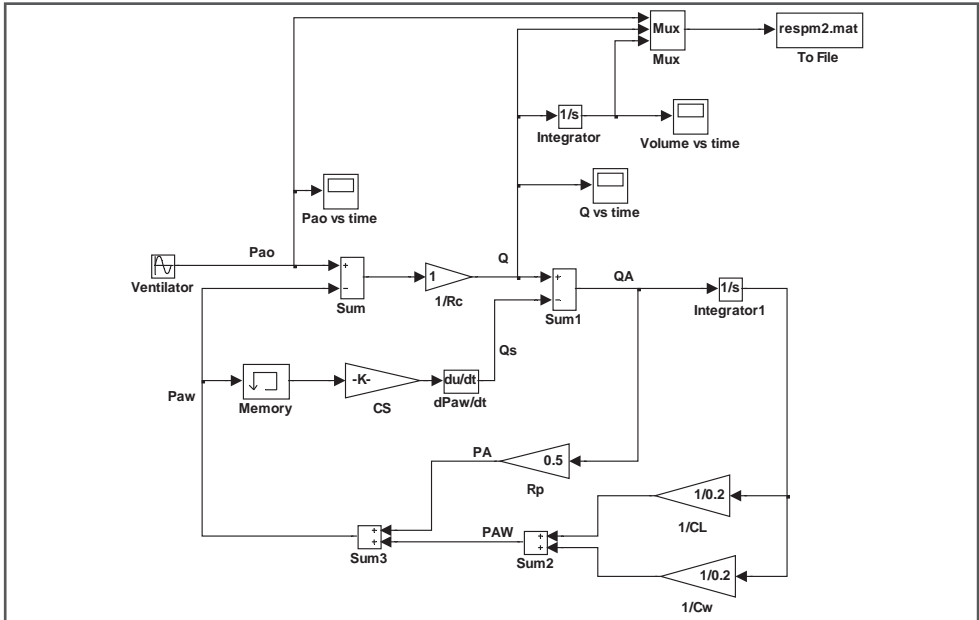


Figure 18. Simulink model implementation according to the equations (4).

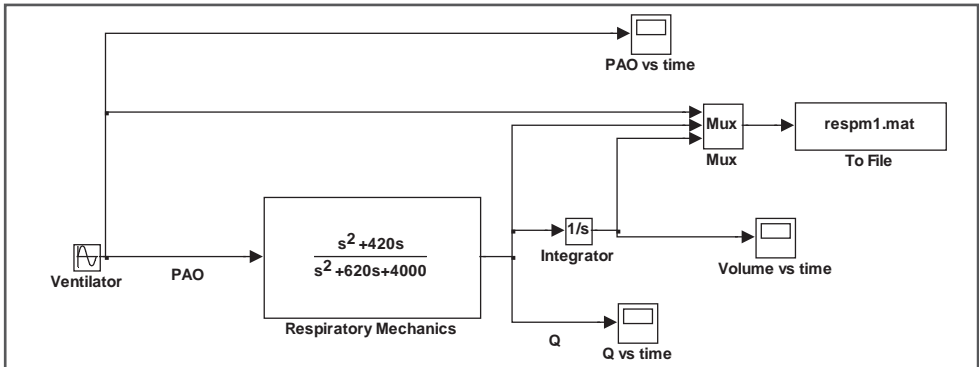


Figure 19. Simulink model implementation using the Laplace transform according to the equation (7).

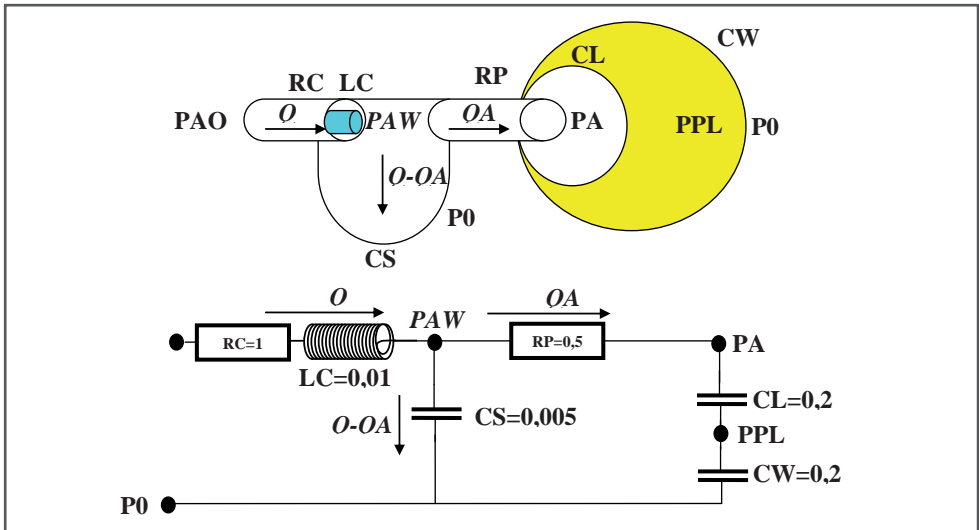


Figure 20. A simple pulmonary mechanics model taking inertia into account (hydraulic and electrical analogy).

might take into account air flow inertia (see Figures 17 and 20). The description of the air flow in the lungs belongs in the pneumatic domain. However, if we disregard the compressibility of gases, we can describe the model using the hydraulic domain. The same formal expression can be provided by an electrical analogy.

It is interesting that the individual fundamental elements have the same formal expression (Fig. 22) in different domains (electrical, hydraulic or pneumatic). This is due to the general system properties of the real world, where voltage or pressure correspond to generalized effort and electric current or medium flow correspond to generalized flow, as the case may be.

To build the pulmonary mechanics model in Modelica, we will need to define the equations of three elementary classes, whose instances we will use in the model. To express the resistance of the respiratory tract, we will use an instance of the Resistor class. The elastic respiratory tract, alveoli and chest will be described as elastic bags using an instance of the Capacitor class and the air flow inertia will be expressed using an instance of the Inductor class.

The fragment with an equation notation in the “Resistor” class, describing the relation between variables expressing the resistance (R), pressure gradient (v) and flow (i) in Modelica, is simple, according to Ohm’s law:

equation

$$R * i = v;$$

end Resistor;

The “Capacitor” class is used to describe an elastic bag expanded by air flow at the input. The compliance (C) characterizes the level of “expansibility” of the bag wall due to the pressure difference (v) between the air pressure forcing air into the bag and the pressure outside the elastic bag. The flow rate of air coming to the bag (i) is then described by the following equation in the Modelica language (where “der” means derivative):

equation

$$i = C * \text{der}(v);$$

end Capacitor;

The inertial element will be implemented in the model by means of the “Inductor” class. The force that accelerates air flow is the pressure gradient. According to Newton’s law, the acceleration of flow, i.e. the first derivative of flow $\text{der}(i)$, is proportional to the pressure gradient (v) and inversely proportional to the weight of the selected gas column, called inertance (L). We can thus describe the relation between a change in the flow rate (i) and the pressure gradient (v) depending on inertance (L) using a simple equation in the “Inductor” class:

equation

$$L * \text{der}(i) = v;$$

end Inductor;

Instances of the above-mentioned fundamental elements are interconnected in a network by means of connectors – two interconnecting connectors, labelled “p” and “n”, are defined for each of the elements. Voltage, or pressure for the hydraulic or pneumatic domain, is fed to each of them ($p.v$, $n.v$) when connected and an electric current or medium flow ($p.i$, $n.i$) can flow through the connectors.

Connectors are instances of special connector classes, in which the variables used for interconnection are defined. Components can be interconnected by means of connectors that are instances of the same connector classes (the “interconnection sockets” must be of the same type). In our case, connectors “p” and “n” are instances of the “Pin” connector class, which is able to interconnect voltages or pressures ($p.v$, $n.v$) and flows ($p.i$, $n.i$) with the environment. Values from the connectors are interconnected with the values of the variables (i) and (v) inside the individual fundamental elements. As a rule, flow does not disappear anywhere in any of the above-mentioned fundamental elements – what flows into an element also

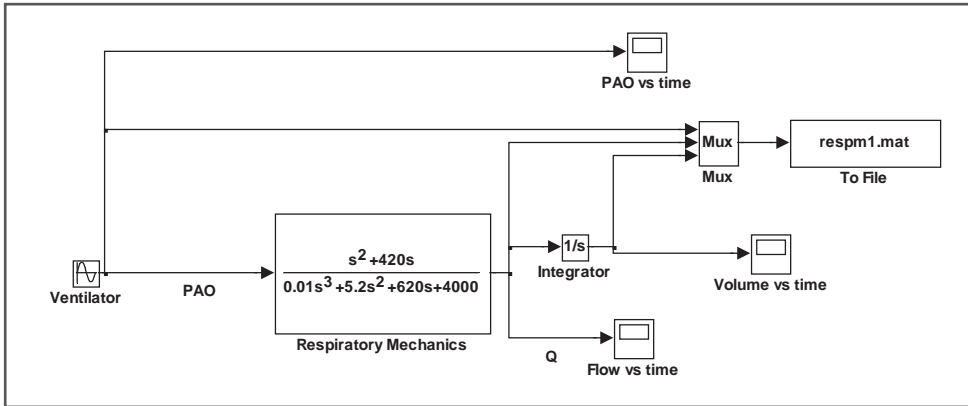


Figure 21. Simulink model implementation using the Laplace transform according to the equation (10).

flows from it ($i=p.i=n.i$), and the appropriate gradient is calculated from the difference in voltages or pressures ($v=p.v-n.v$). Implementing this requirement is simple – since Modelica is an object-oriented language, all three of the above-mentioned classes of fundamental elements will have a common ancestor (OnePort) from which they will inherit connectors “p” and “n” as well as the following equations:

equation

$$v = p.v - n.v;$$

$$0 = p.i - n.i;$$

$$i = p.i;$$

end OnePort;

The equations will thus connect the values of the pressures or voltages fed from the environment to connectors “p” and “n” ($p.v, n.v$) with the pressure or voltage gradient (v) and express the same value of (electric or hydraulic) flow at both connectors ($p.i, n.i$) and inside the component (i).

Connector classes define the manner in which Modelica components communicate with one another. Figuratively speaking, by defining connector classes we define the types of “sockets”. In connectors we define individual variables that the connector will use to interconnect a component with its environment.

It is defined for each variable in a connector whether it represents a flow (then the variable is identified with a “flow” attribute) or

not (“non-flow” variables). This differentiation is important for the correct interpretation of the interconnection of individual components (instances of element classes) through the appropriate connectors (see Fig. 23). For flow variables, it is obvious that we must make sure the entity in question (whose flow the variable characterizes) neither disappears nor accumulates anywhere in the interconnection. Therefore, the sum of all interconnected variables with the “flow” attribute must be zero (as according to Kirchhoff’s law in the electrical domain). For non-flow variables, an interconnection defines that their values must be the same for all interconnected connectors (according to Kirchhoff’s first law). By interconnecting the instances of individual fundamental elements through connectors, we express the requirement of the zero algebraic sum of the values of interconnected flow variables and the requirement of the equality of the values of interconnected non-flow variables.

Each Modelica class can have a graphical representation – this is important especially for depicting the interconnection of instances where components are interconnected to create a clear graphical structure of a model. That is why we can also define an icon for each class in Modelica. The icon can be animated.

We can then create a model graphically in Modelica, by interconnecting the instances of individual elements that we select from a library with the mouse and setting the val-

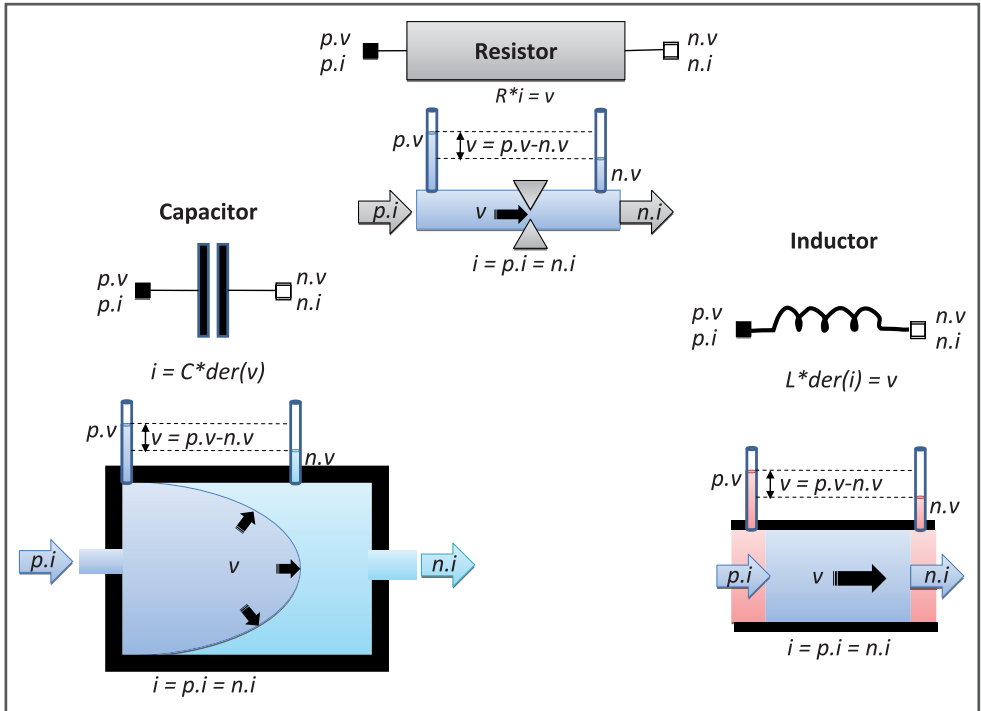


Figure 22. The hydraulic and electric elements are from different domains but have the same formal description. The analogy of voltage (v) in the hydraulic domain is pressure, the analogy of current (i) in the hydraulic domain is a stream of fluid (and a stream of gas in the pneumatic domain). Hydraulic resistance (R) follows Ohm's law in the same way as electric resistance (the voltage difference is just replaced with the pressure gradient and the current is replaced with the flow rate). The hydraulic analogy of a capacitor is an elastic bag expanded by the difference in pressures inside and outside the bag. The analogy of the electric capacity of a capacitor (C) is the compliance of the elastic bag wall. When we include inertia in a hydraulic system, the force that accelerates fluid flow is the pressure gradient. According to Newton's law, the acceleration of flow, i.e. the first derivative of flow $der(i)$, is proportional to the pressure gradient (v) and inversely proportional to the weight of the selected fluid column, called inertance (L). In the electrical domain, inertance corresponds to coil inductance. Each element from the hydraulic or electric domain has two interconnecting connectors through which electric current or medium flow ($p.i$, $n.i$) flows in and out; as a rule, the running flow (i) never disappears in the element (i.e. $i=p.i=n.i$). Simultaneously, voltage or pressure ($p.v$, $n.v$) is connected to the connectors by interconnecting into a network, and a voltage gradient or a pressure gradient (v) builds up in the element.

ues of the appropriate parameters in a dialogue box.

For the implementation of our pulmonary ventilation model, we need to interconnect instances of the “Resistor”, “Capacitor” and “Inductor” elements.

However, we do not have to program the fundamental elements we need from the very beginning – Modelica includes extensive libraries from various physical domains (electric, hydraulic, mechanic, etc.) where such elements can be found.

In our specific case, we can take advantage of e.g. the visual components of electrical circuits for a quick solution – we will create

the individual instances (RC, RP, CL, CW and CS), enter the appropriate values of parameters (C and R) and interconnect the components with a connector.

The result is shown in Fig. 24. Comparing the model structure implemented in Modelica with the original schematic drawing showing the model structure (Fig. 17), we can see that the Modelica solution is straightforward and (unlike the Simulink implementation – see Figs. 18 and 19) the structure of the model corresponds to the structure of the modelled reality.

Increasing the complexity of the model by including an inertial element does not cause

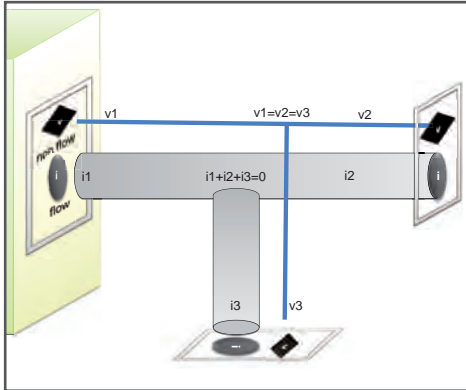


Figure 23. Interconnection of Modelica components by means of acausal connectors. The values of flow-type connector variables (here the variable i) will be set so that the algebraic sum of the values of all inter-connected flows is zero. The values of other (non-flow) variables (here the value of v) will be set to the same value at all interconnected connectors.

any significant trouble – we just pick up the appropriate inertial component (LC) from the library with the mouse, set the value of its parameter (L) and interconnect it in the model. The structure of the model implemented in Modelica, shown in Fig. 25, corresponds to the structure of the modelled reality (see Fig. 20), while the structure of the Simulink implementation (Fig. 19) corresponds more to the method of solution for the model's equations.

The fundamental elements of the simulated reality can have very trivial notation of relations between the variables in question. A resistor, capacitor or coil from the electrical physical domain or their hydraulic analogies are illustrative examples of this.

A complex system for calculation will ensue from interconnecting the fundamental elements in networks – a system of equations will result from their mutual interconnections. Their numerical solution in causal simulation tools may not be trivial at all – e.g. more complex R-C-L models of circulation or respiration implemented in Simulink are very complex (see e.g. circulation models in our Simulink library, Physiobank – <http://www.physiome.cz/simchips>).

In Modelica, we do not have to bother with the method of solution for equations. Instead, more attention should be paid to the definition of equations in individual elements and interconnection of their instances (individual components).

In Modelica, the acausal tool itself will take care of the algorithm for solving the resulting system of equations and we can monitor the appropriate flows and pressures in various places in the simulated circuit when the simulation is launched.

Causal and acausal connectors

The acausal connector interconnection of components is implemented by means of two types of variables: one representing a flow – for this, it holds true that the sum of flow values in all connected nodes is zero (because no medium accumulates in the area of branching into connected nodes); and one whose value remains the same in all connected nodes. It is advisable that each variable with the flow attribute is accompanied by a non-flow variable representing the generalized effort in relation to the flow variable in the connector interconnection.

Unlike Simulink components (which have defined component inputs and component outputs), we do not define what is an input and what is an output in an acausal interconnection. An acausal Modelica component does not calculate output values from input values. The interconnection of Modelica components by means of acausal connectors interconnects the equations in individual components into systems of equations.

In addition to acausal linking connectors, Modelica classes may include causal input connectors that are used to feed actual input variables from the environment, as well as causal output connectors that serve to send output variables to the environment.

In addition to equations, Modelica classes may also include a precisely defined algo-

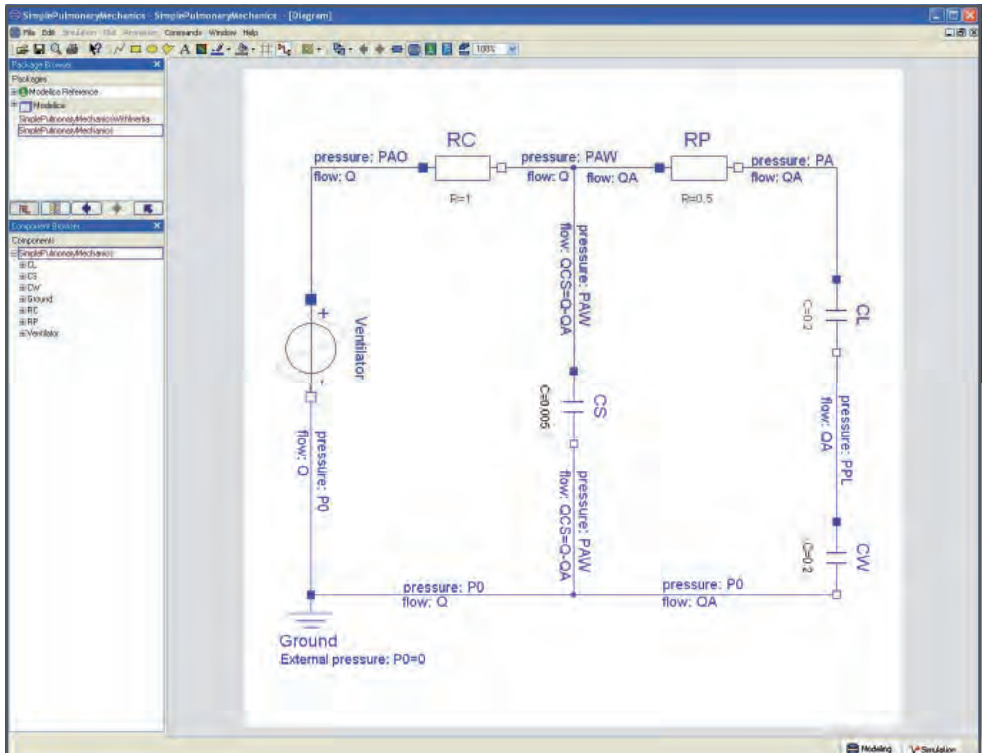


Figure 24. The implementation of the pulmonary mechanics model (according to Fig. 17) in Modelica resembles the modelled reality much more than the implementation in Simulink.

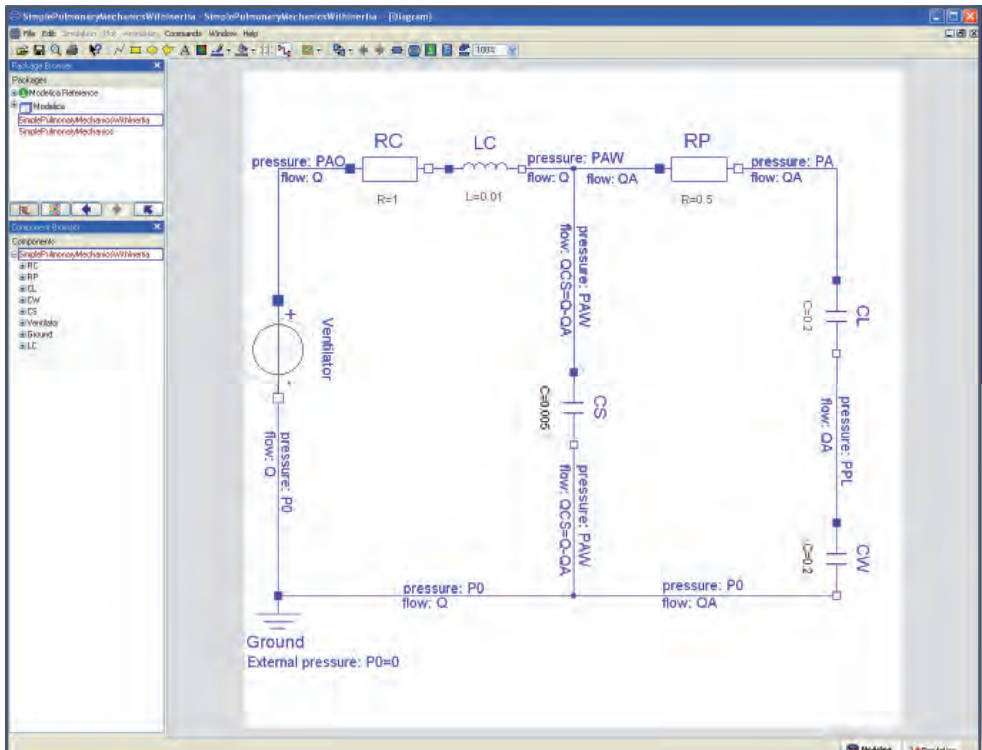


Figure 25. In Modelica, implementing the pulmonary mechanics model taking into account the inertial element (according to Fig. 20) merely requires adding the LC inertial component.

rithm for the calculation of output values from input values (a typical example is the modelling of functional dependencies).

Modelica components are thus interconnected using both acausal links and causal, directional inputs and outputs.

Causal connectors usually distribute signals – e.g. in a blood circulation model, signal causal inputs may contain signals used to set resistance values in components representing the resistance of the circulatory system.

Consequently, a Modelica model is usually represented by a graphical set of components interconnected using both acausal and causal links. Components are instances of Modelica classes whose structure may also be represented as a network of interconnected instances.

An example of the definition and use of an acausal element – elastic compartment

Let us see a simple example of the definition and use of a Modelica class. When modelling the dynamics of blood vessels, we often need an elastic (inflatable) compartment.

Therefore we will define a class named *VascularElasticBloodCompartment* whose instances will be elastic, acausally interconnectable compartments that can be connected to the “distribution” of a fluid through an acausal connector – the fluid may flow to/from the compartment at a certain rate and under a certain pressure. We can assign a graphic icon to each class representing a model or connector in the programming environment. We can create an icon for our elastic compartment, too (Fig. 26).

This is not just a school example – we take this compartment into account in our Modelica implementation of an extensive model of physiological functions, “Quantitative Human Physiology” (Abram 2007, Coleman et al, 2008). Fig. 28 shows an example of the use of instances of the elastic com-

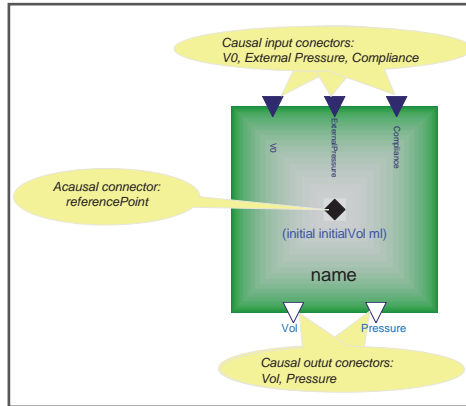


Figure 26. Modelica allows creating an icon for each created class representing a model or a connector, which will be used to interconnect instances of the class with other instances using graphic tools. The result is a model structure consisting in interconnected instances, very close to the modelled reality. Here we have created an icon for the elastic compartment, having one acausal connector (black diamond), three connectors for signal inputs and two connectors for signal outputs. Each instance of the elastic compartment will have this icon, displaying the actual value of the initial volume (specified as a parameter) instead of “initialVol” and the name of the instance instead of “name”.

partment in our implementation of this extensive model.

We can imagine the elastic vascular compartment (Fig. 27) as an inflatable bag with one **acausal interconnecting connector** (let us name it e.g. “*ReferencePoint*”) that we will use to connect to the environment – this connector will provide us with two variables:

- flow “*ReferencePoint.q*”;
- pressure “*ReferencePoint.pressure*”

If the connector is connected to the environment through a connector, the pressure value will truly be the same in all nodes connected to the compartment, and the flow will be distributed to all connected nodes so that its algebraic sum will be zero (nothing ever accumulates in the area of branching) – see the example of the component connection in Fig. 28.

Three signal (causal) inputs will enter the compartment from the outside:

- Basic charge “*V0*” – the value of the volume that must be reached before

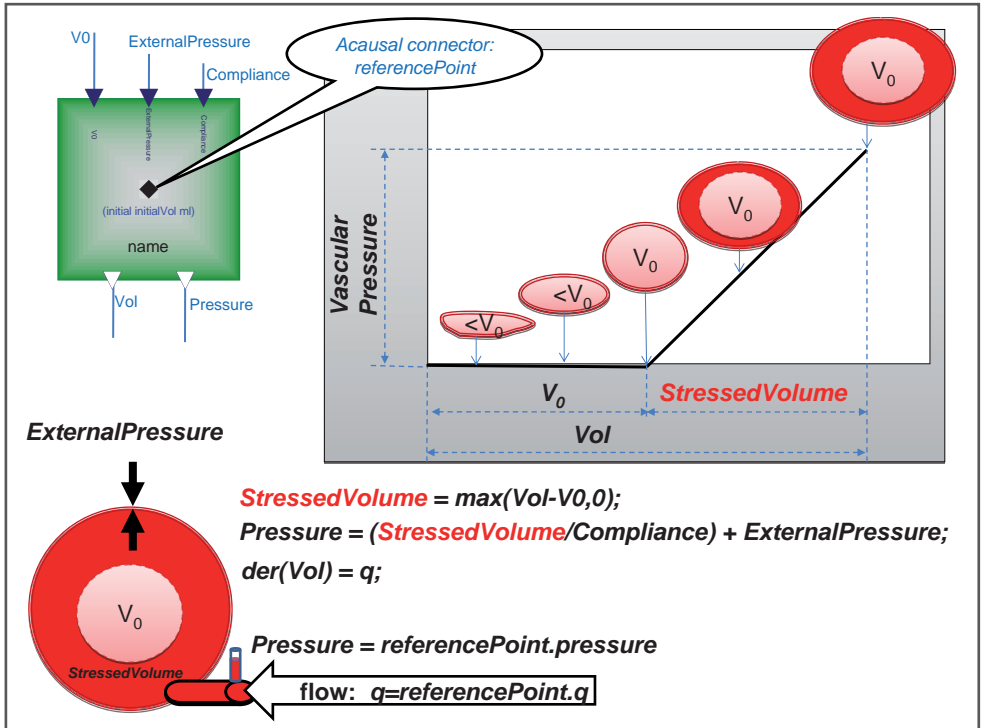


Figure 27. The concept of an elastic vascular compartment is based on the idea that when a blood vessel fills with blood, the pressure in the vessel is determined only by the external pressure on the vessel until a certain residual volume (V_0) is achieved; the elastic and muscle fibres in the blood vessel will then start to tense and compress the volume of blood in the vessel with the VascularPressure pressure. If we label the volume of fluid in the blood vessel Vol , then the volume of blood stressing the vessel ($StressedVolume$) will determine the Pressure inside the vessel depending on its Compliance and on the external pressure on the vessel ($ExternalPressure$). The vascular compartment is connected to the system by means of the ReferencePoint connector, through which blood may flow into the compartment (at the rate of $referencePoint.q$) under pressure ($referencePoint.pressure$).

the pressure in the elastic compartment starts increasing. If the volume is less than zero, the pressure in the compartment will be zero.

- Outer, external pressure “*ExternalPressure*” – the pressure of the ambient environment on the elastic compartment.
- “*Compliance*” of the elastic compartment – the pressure in the compartment will be inversely proportional to it if the compartment volume exceeds the basic charge.

Two (causal) signal outputs will go from the compartment to its environment:

- Information about the compartment’s current volume, “*Vol*”
- Information about the pressure inside the compartment, “*Pressure*”

It is useful to design another parameter for the compartment (whose value will be read before the start of simulation), which would specify its initial charge:

Initial compartment volume, “*initialVol*”

We can also design an icon to display the elastic component in the programming environment.

The actual fragment of code describing the behaviour of the elastic compartment looks like this in Modelica:

```
model VascularElasticBloodCompartment
extends QHP.Library.Interfaces.BaseModel;
```

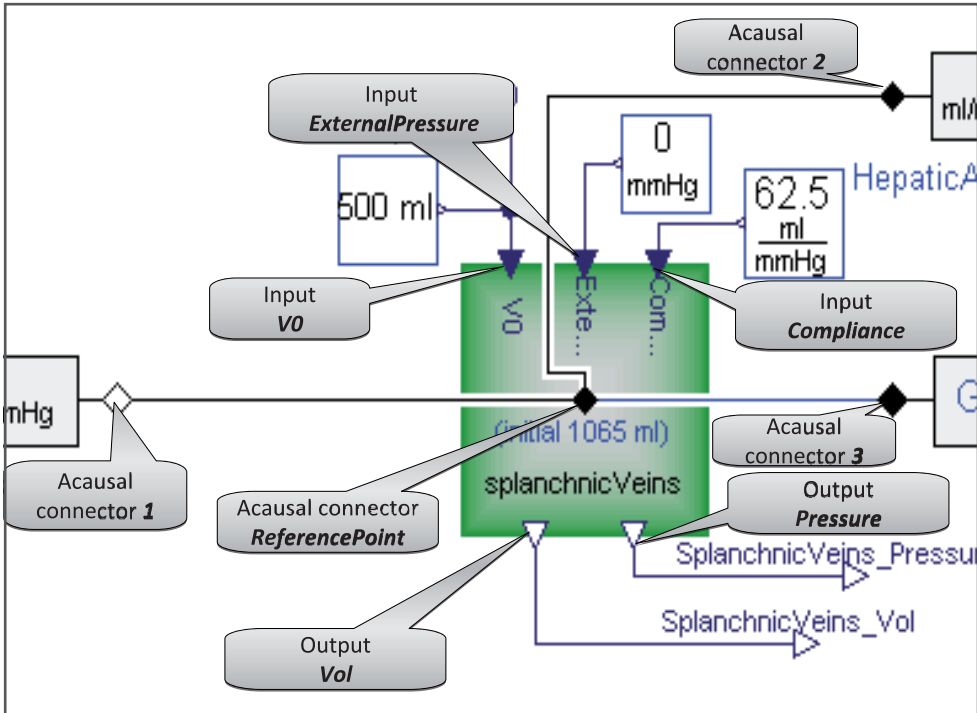


Figure 28. The instance “splanchnicVeins” of the elastic compartment “VascularElasticBloodCompartment”. The acausal connection with the appropriate connectors at controllable resistors (labelled “connector1”, “connector2” and “connector3” here) will interconnect the equations in the elastic compartment instance “splanchnicVeins” into a system of equations of all the interconnected elements. The pressure value will be the same at all interconnected connectors:
 $\text{splanchnicVeins.ReferencePoint.pressure} = \text{connector1.pressure} = \text{connector2.pressure} = \text{connector3.pressure}.$

Real StressedVolume (final quantity = “Volume“, final unit = “ml”);

parameter Real initialVol (final quantity = “Volume“, final unit = “ml”)

„initial compartment blood volume“;

...

initial equation

$\text{Vol} = \text{initialVol};$

equation

$\text{der}(\text{Vol}) = \text{referencePoint.q};$

$\text{StressedVolume} = \max(\text{Vol} - \text{V0}, 0);$

$\text{Pressure} = (\text{StressedVolume} / \text{Compliance}) + \text{ExternalPressure};$

$\text{referencePoint.pressure} = \text{Pressure};$

end VascularElasticBloodCompartment;

The first line declares the model class; in addition, there is the declaration of a real variable, “StressedVolume”, whose physical

units will be checked. This is not just a question of code clarity and readability. The check of unit compatibility will enable us to avoid a very hard-to-find error, when we exchange connectors in interconnections by mistake (if units are found to be incompatible, the check will not allow us to create the wrong interconnection at all).

Then there is the declaration of an “Initial-Vol” parameter, whose physical units will be checked as well. And then there is the equation section. The initialization of the compartment’s initial volume, i.e. the variable “Vol”, is declared first. The other lines in the equation section declare four equations. The first one is a differential equation – the derivative of the volume “der(Vol)” equals the inflow “q” from the connector “referencePoint”.

The next equation declares that the value of the elastically stressed volume “Stressed-

$Volume\dot{Z}$ will be calculated as the difference between the compartment volume “ $Vol\dot{Z}$ ” and the value of its basic charge “ $VO\dot{Z}$ ” (which is an input); the equation also says that the value of the compartment volume may never drop down to negative values.

The third equation declares the relation between the “ $Pressure\dot{Z}$ ” in the compartment, the value of the “ $StressedVolume\dot{Z}$ ”, the “ $Compliance\dot{Z}$ ” and the “ $ExternalPressure\dot{Z}$ ”. We would like to repeat that these are not assignments but equations. The equation could also be written like this in Modelica:

$$Pressure - ExternalPressure = (StressedVolume / Compliance);$$

The last equation interconnects the value of “ $Pressure\dot{Z}$ ” in the compartment with the value of the pressure interconnected with its environment by the acausal connector through the “ $referencePoint.pressure\dot{Z}$ ”.

The value of “ $Pressure$ ” is also a signal output from the compartment – as a signal, it can be fed to other blocks – but it is a causal output (signal) variable and its value cannot be affected by what we connect it to. However, the situation is different with the interconnection from the acausal connector. When we interconnect an instance of the elastic compartment with other elements through the acausal connector, the four equations in the compartment will become part of the system of equations defined by the interconnection and the values of the variables in the elastic compartment instance will depend on the solution of the originated system of equations.

Hybrid models

Continuous dynamics expressed by a system of algebraic differential equations is often enough for the mathematical description of real-world models. However, we frequently need to represent discontinuous, discrete behaviour (which is often an approximation of quick continuous processes in physical systems) and continuous dynamic systems

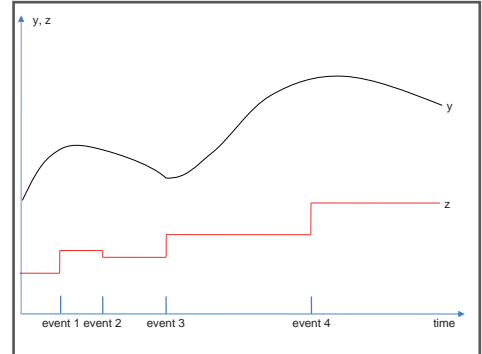


Figure 29. An example of the behaviour of real variables in hybrid systems. The continuous time variable “ y ” changes in time (its value does not have to be continuous – e.g. it may change discontinuously, perhaps in a jump, in response to an event). The real discrete-time variable “ z ” only changes its values at event instants.

themselves are not enough for the description of real-world processes – examples include the opening and closing of valves in the hydraulic and pneumatic domain, the behaviour of diodes in the electrical domain or the switching on/off of genes, the creation and transmission of nerve impulses or the opening and closing of ion channels in the biological domain. Discrete event dynamic systems are frequent in the description of technical applications. Discrete hierarchical state automata are a very powerful tool for the formalized description of processes and their interactions (Harel, 1987).

When modelling large systems, it is often useful to combine discrete and continuous description to a lesser or greater extent. Such “hybrid” models can combine discrete and continuous time variables, and generate and react to various events (see Fig. 29). Hybrid models are supported in modern development simulation environments. For example, a continuous dynamic system model in Simulink can be combined with hierarchical state automata created in a special modelling tool, Stateflow – the values of variables in Simulink can change the states of automata in Stateflow, and Stateflow can switch calculation blocks in Simulink by means of generated events, changing the calculation procedure.

However, acausal development tools can directly change the used equations (not just the method of solution). A small illustrative example can be the modelling of the average blood volume in a ventricle (see Fig. 30).

A ventricle is modelled as a continuous pump with a variable internal volume.

The ventricle model is connected to the circulation by means of acausal connectors “ q_in ” and “ q_out ”. These connectors interconnect the flow of blood into (“ q_in ”) and out of (“ q_out ”) the ventricle. The change of blood volume in the ventricle will be determined by the algebraic sum of flows in both acausal connectors. In Modelica, this will be written as follows:

$$\text{der}(\text{Volume}) = q_in.q + q_out.q;$$

The model has two causal inputs – one is the current flow in the ventricle (“ BloodFlow ”) and the other is the required volume of blood in the ventricle in the steady state (“ $\text{VentricleSteadyStateVolume}$ ”). If that volume is greater than the current ventricle volume (“ Volume ”), then inflow to the ventricle will be set to a larger value than the outflow, proportionally to the difference between the required value and the actual value:

$$q_in.q = \text{BloodFlow} + (\text{VentricleSteadyStateVolume} - \text{Volume}) * K;$$

Outflow from the ventricle (“ $q_out.q$ ”) will be set to the value of “ BloodFlow ” with a negative sign, because it flows out of the compartment:

$$q_out.q = -\text{BloodFlow};$$

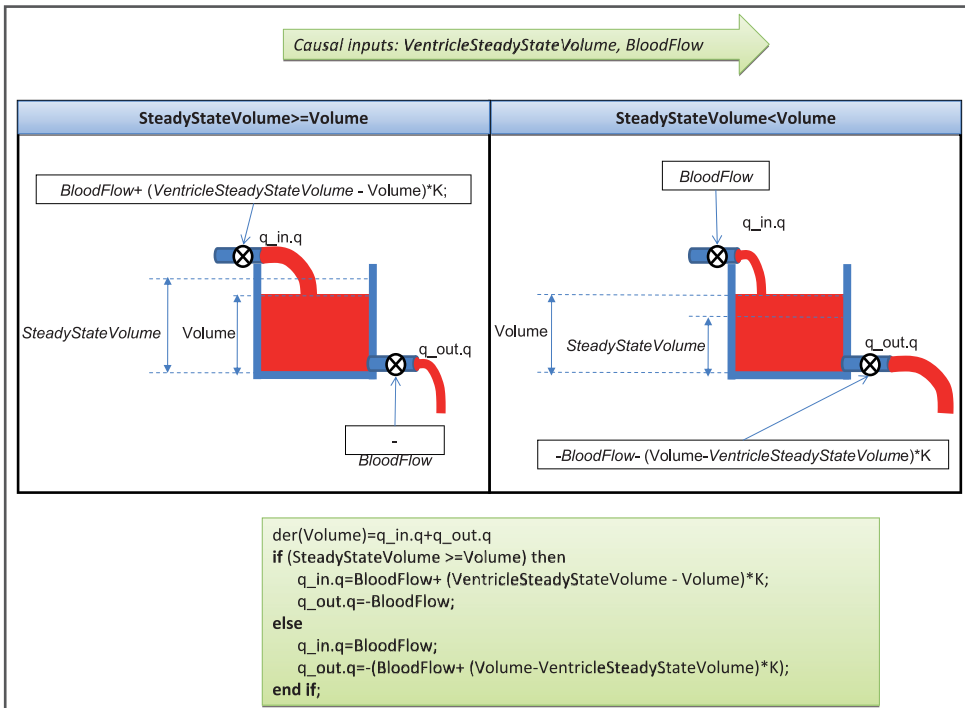


Figure 30. The Modelica acausal modelling tool allows changing the system of equations in use dynamically. The illustration shows the hydraulic analogy of a ventricle volume model represented as a continuous pump with variable internal volume. Two acausal connectors (q_in) and (q_out) interconnect the component with its environment; the component receives the value of blood flow (BloodFlow) and the required value of blood volume in the ventricle ($\text{VentricleSteadyStateVolume}$) as its causal inputs. Equations calculate the volume of blood in the ventricle (Volume) and blood inflow and outflow values ($q_in.q$, $q_out.q$). The equations used will vary depending on whether or not the required volume of blood is greater than the current volume of blood in the ventricle (i.e. whether $\text{SteadyStateVolume} \geq \text{Volume}$).

Alternatively, when the required value of blood volume in the ventricle (*VentricleSteadyStateVolume*) is less than the actual value (*Volume*), the inflow of blood will be set to *BloodFlow* and the outflow of blood will be set to a larger value than the inflow, proportionally to the difference between the actual value and the required value. The equation notation fragment in Modelica then looks like this:

```
model VentricleVolumeAndPumping;
.
equation
  der(Volume) = q_in.q + q_out.q
    if (SteadyStateVolume >= Volume) then
      q_in.q = BloodFlow + (VentricleSteadyStateVolume - Volume) * K;
      q_out.q = -BloodFlow;
    else
      q_in.q = BloodFlow;
      q_out.q = (BloodFlow + (VolumeVentricleSteadyStateVolume) * K);
    end if;
end VentricleVolumeAndPumping;
```

Two equations are then switched over in the model's system of equations, depending on the values of the variables *Volume* and *VentricleSteadyStateVolume*. At first sight, the notation looks like an assignment (as in standard programming languages) but they are equations. An equivalent notation may look like this:

```
model VentricleVolumeAndPumping;
.
equation
  delta = (VentricleSteadyStateVolume - Volume) * K;
  der(Volume) = delta;
  q_in.q + q_out.q = delta;
  if (delta < 0) then
    q_in.q = BloodFlow;
  else
    q_in.q = BloodFlow + delta;
  end if;
end VentricleVolumeAndPumping;
```

Because they are equations, their order does not matter; nor does it matter whether the value of the variable *delta* in the third equation is on the right or on the left.

The actual notation of the equations used in Modelica is even more compact:

```
model VentricleVolumeAndPumping;
.
equation
  delta = (VentricleSteadyStateVolume - Volume) * K;
  der(Volume) = delta;
  q_in.q + q_out.q = delta;
  q_in.q = if (delta < 0) then BloodFlow else BloodFlow + delta;
end VentricleVolumeAndPumping;
```

Modelica allows describing discrete and continuous systems acausally, providing many possibilities of combining models with discrete and continuous parts. Details can be found in Fritzon, 2003.

Combining acausal and causal (signal) connections in hierarchically arranged models

Modelica makes modelling large systems easier and more controllable and supports their hierarchical decomposition.

Modelica's object-oriented architecture supports the structuring of models into suitable parts having a coherent meaning so that they can be examined separately under certain conditions or re-used (whether in a different place in the same model or in another model), greatly enhancing the clarity of the created models. That is why we create large, reusable libraries of Modelica "simulation chips" in Modelica and each model is usually accompanied by an extensive, hierarchically arranged library of elements. Hierarchical components can be clicked to expand, which will reveal their internal structure.

An example of the hierarchical structure of a Modelica program is the “*VascularCompartments*” class (see Fig. 31), which implements a part of the blood circulation subsystem and makes use of an instance of the above-mentioned class “*VascularElasticBloodCompartment*”. Blood flows through acausal connectors between elastic compartment instances, resistances of individual parts of the vascular system and two pumps modelling the activity of the right and left ventricles. The component also uses causal signal connections. An entire set of signal connections (coming from outside the component) is distributed e.g. by the “*OrganBloodFlowSignals*” bus. Input signal connections control the value of the peripheral resistors and the pumping functions of the right and left ventricles. The structure of the model represents the structure of

the modelled reality much better and much more clearly than models created in causal modelling environments. Just compare the Modelica model in Fig. 31 to the model shown in Fig. 6, implemented in Simulink. The two models represent roughly the same – the flow through an elastic vascular system and a heart pump (however, the Modelica model has more details). The Simulink model represents the calculation procedure rather than the structure of the modelled system. The advantage of acausal modelling tools is particularly evident in more complex models, where the possibility of hierarchical model decomposition is crucial for success, as it is important for the interconnection of components to always express in an aggregated manner the cardinal relations at a given hierarchical level while details can be obtained by digging

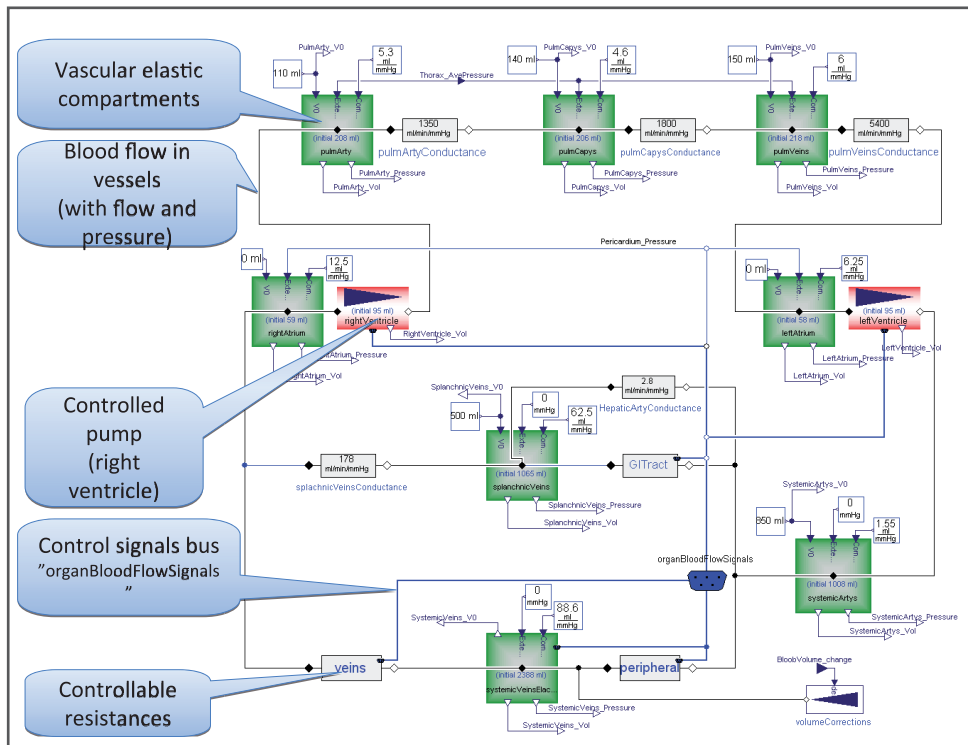


Figure 31. An example of a part of the blood circulation subsystem – an instance of the “*VascularCompartments*” class in Modelica (a part of the Modelica implementation of the large Quantitative Human Physiology model). The model combines acausal and causal (control, signal) connections. In this case, the interconnection by means of acausal connections models the distribution of blood flows and pressures among the individual interconnected components. The model is organized hierarchically; individual blocks can be clicked to expand and represent instances of classes in which equations are specified. The Modelica network thus represents the structure of the modelled system much better than networks in causal modelling tools, which rather represent the calculation procedure.

deeper into the structure of individual components, which will reveal the aggregated structure of the modelled reality at a lower hierarchical level.

For instance, the component representing the pump of the right ventricle is connected to the elastic compartment of the right atrium and the elastic compartment of the pulmonary arteries by means of two causal connectors (distributing the blood flow and blood pressure). Causal signal control inputs are connected to it from the “*organ-BloodFlowSignals*” bus. The “*inside*” of the component is shown in Fig. 32.

The heart is a pulsation pump that first draws blood from the atria into the ventricles during “diastole” – at the end of diastole, the volume of blood in the ventricle equals the end-diastolic volume (EDV). After the end of diastole, the valves between the atrium and the ventricle close and the ventricle starts contracting during “systole”. The appropriate valves open and the right ventricle starts pumping blood out to the pulmonary artery (the left ventricle to the aorta). At the end of systole, the valves between the ventricle and the pulmonary

artery in the right ventricle (and between the ventricle and the aorta in the left ventricle) close – the volume of blood in the ventricle at the end of systole is called end-systolic volume (ESV). The ventricle muscles relax, the pressure gradient between the atrium and the ventricle opens the atrioventricular valves and diastole begins again.

In the ventricle model, the end-diastolic volume (EDV) is calculated in a “diastole” component and the end-systolic volume in a “systole” component. Modelica allows not only designing of the graphic form of icons representing the individual components but also animating the icons (to improve clarity). In the given example, both components have animated curves during simulation, which represent the relation between pressure in the ventricle and the values of ESV and EDV. A dot on the curves represents the current value of EDV/ESV. Blood pressure in the ventricle is derived from the value of the supply pressure in the atrium (this gets to the component from “*q_in*” by means of an acausal connector) and the value of the external pressure in the pericardium – this gets to the ventricle from the signal bus

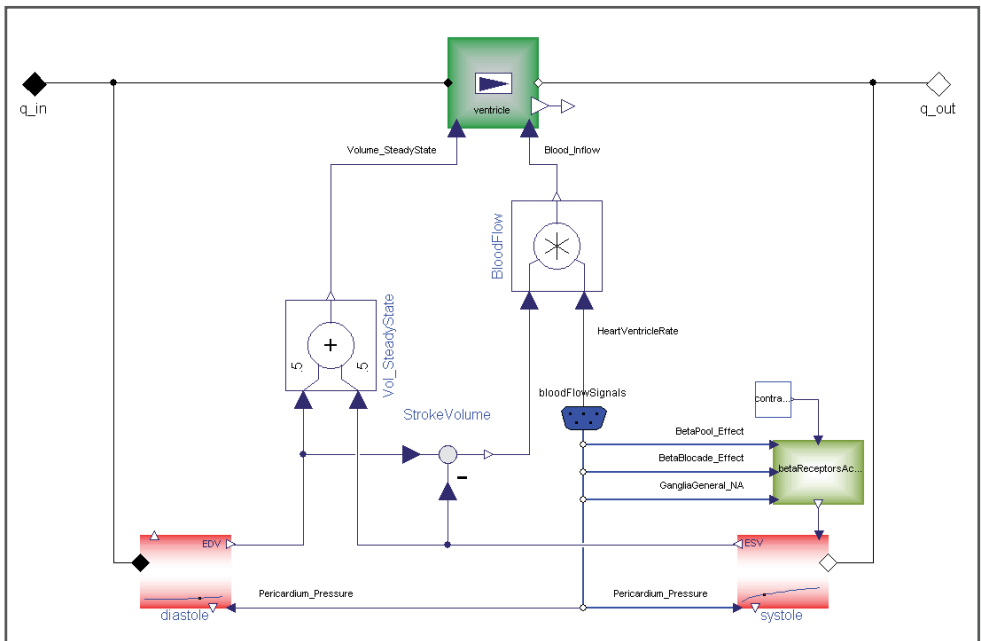


Figure 32. The “inside” of an instance of the right ventricle pump (component “*rightVentricle*”) from Fig. 30. The ventricle is modelled as a continuous pump with variable internal volume.

“BloodFlowSignals” by means of a causal connector, “Pericardium_Pressure”. In the “systole” component, blood pressure in the right atrium at the end of systole is derived from the value of the counter-pressure in the pulmonary artery (or pressure in the aorta in the left ventricle) – by means of an acausal connector, “q_out”, and the value of the external pressure in the pericardium (by means of the causal connector “Pericardium_Pressure”). During systole, the dependency of the ESV value on the end-systolic pressure is also affected by the stimulation (or blocking) of “beta receptors”, which results in changes in the contractile power of the heart muscle. A detailed description of equations that describe this dependency is contained in “BetaReceptorsActivityFactor”, a component whose output is the causal input for the “systole” component.

The ventricle model in Fig. 32 is not expressed as a pulsation pump but rather as a continuous pump with variable internal volume. We do not model pumping “beat by beat” but by the average cardiac output per minute.

The systolic volume is calculated first (in the component “StrokeVolume”), as the difference between the end-diastolic (EDV) and end-systolic (ESV) volumes. The value of the blood flow per minute is calculated (in the “BloodFlow” multiplier) from the systolic volume multiplied by the heart rate. The value of the heart rate (“HeartVentricleRate”) comes from the outside, from the “bloodFlowSignals” bus.

The average volume of blood in the ventricle is estimated as the arithmetic mean (“Vol_SteadyState”) of the maximum heart charge in diastole (EDV) and heart volume at the end of systole (ESV).

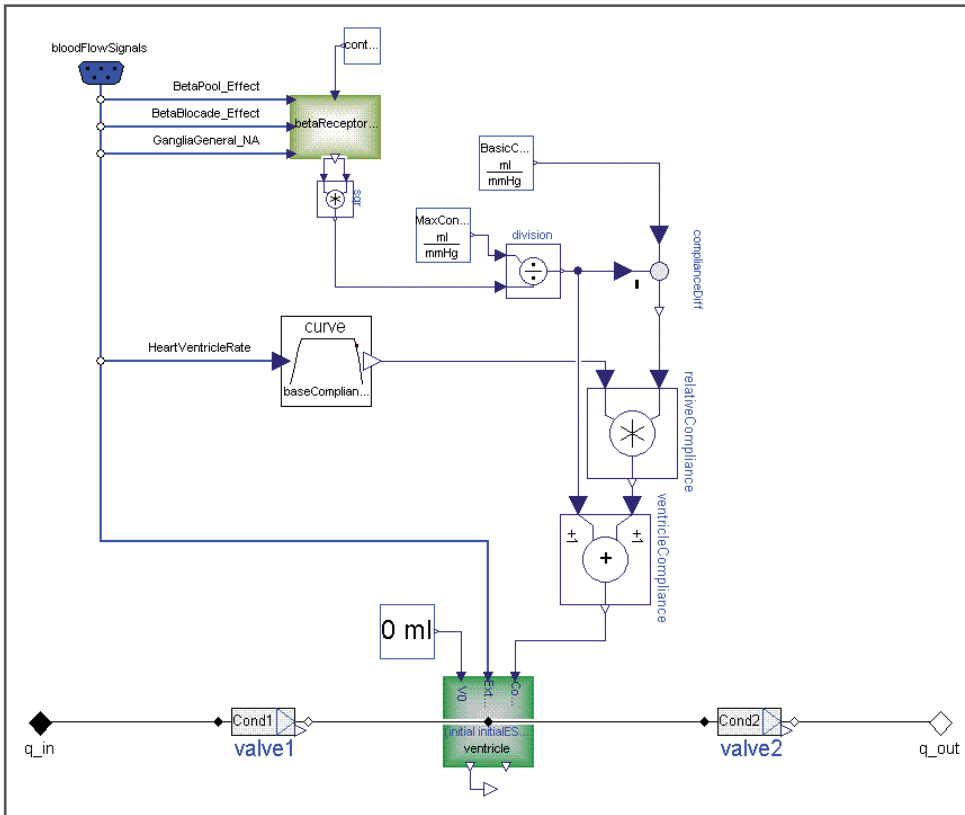


Figure 33. A ventricle model with valves, which generates a pulsating blood flow beat by beat. It has the same outer interface for interconnecting into the model of a higher hierarchical level as the pump model.

The ventricle is represented (by the “ventricle” component) as a continuous pump that has variable internal volume (the component is an instance of the model from Fig. 30). The pump is connected to the blood circulation by means of acausal connectors (“q_in” and “q_out”). It receives the calculated value of the cardiac output (Blood_inflow) and the required average value of the pump’s internal volume (“Volume_SteadyState”) by means of two causal connectors.

The model of the heart approximated as a continuous pump is sufficient (and sufficiently quick) for a number of applications in medical simulators. However, if we wish to model e.g. various valve defects, we have to use a more detailed model, describing the behaviour of the ventricle beat by beat.

Replacing a simpler component with a more complex component does not have to mean reworking the entire model. Model notation

in Modelica allows a very elegant exchange of components as different variants of classes with the same interface.

For example, it is possible to exchange the instances of the left and right ventricle models (“rightVentricle” and “leftVentricle” components) inside the blood circulation subsystem model (see Fig. 31): Instead of the continuous pump model of the ventricles (Fig. 32), we can insert instances of a more complex model into the diagram, generating blood flow beat by beat. We just have to cast the instances of the left and right ventricles.

The basis of the ventricle model with valves that generates a pulsating blood flow beat by beat (Fig. 33) is an elastic compartment (“ventricle”), which has a generated oscillating value of compliance (unlike the elastic compartment used in the blood vessels). The frequency of the oscillations is determined by the number of heartbeats

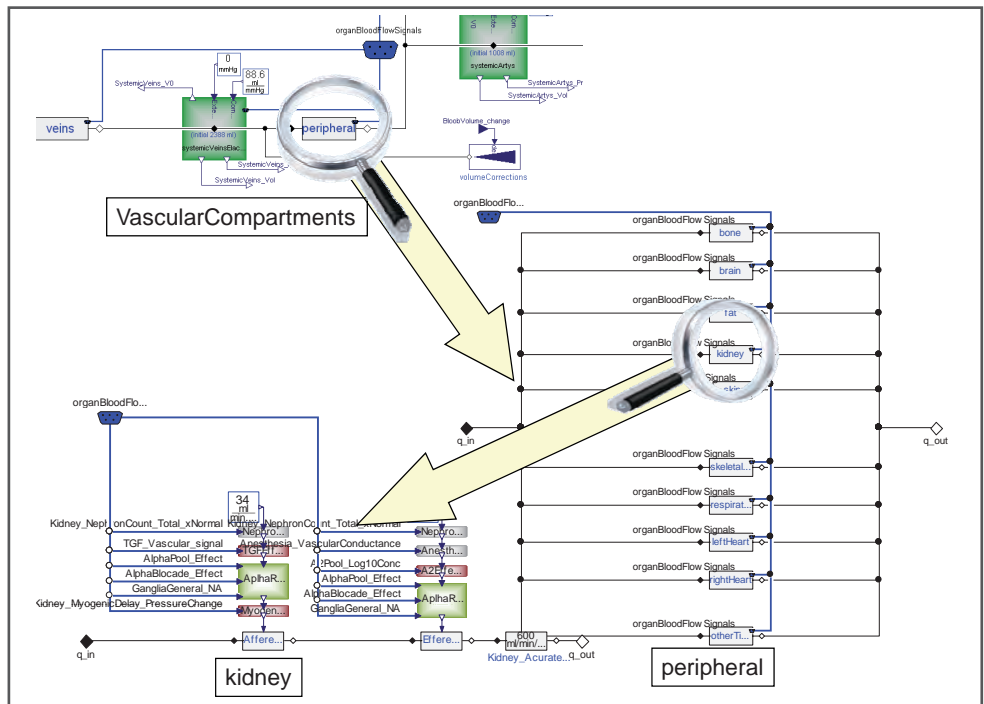


Figure 34. Hierarchical arrangement of models in Modelica. The “VascularCompartments” component (from Fig. 30) has one peripherally controlled resistor named “peripheral”. When clicked, it will expand and show a number of controlled resistors connected in parallel. Clicking one of them – named “kidney” – will display complexly controlled resistors in the kidneys. The combination of acausal and (causal) signal connections and the wide range of graphical options for displaying the modelled relations allow the creation of hierarchically structured and “self-documenting” models.

per minute. The shape of a single compliance change period (the “curve” component) expresses the properties of the heart muscle. The amplitude is affected by the stimulation and blocking of the beta receptors. At last, the direction and rate of blood flow in the ventricle is derived automatically from the properties of the valve components (“valve1” and “valve2” components) and from the pressure gradients.

A simple valve model can be represented as an analogy of a series connection of an ideal diode with a resistor. An alternative (more complex) model of the valves will allow the modelling of various valve defects.

By exchanging components of different complexity with the same interface, we can create model instances of different complexity as needed for their application use.

Modelica supports the possibility to exchange individual components by allowing defining interfaces with a variable number of control (input, causal) signals. Depending on the number of control signals, components may be more complex or, conversely, simplified, and their function may be tested when connected to a model of a higher hierarchical level. This major advantage can be used efficiently not only when debugging complex models but also when identifying a model from experimental data.

Making use of the hierarchy and component structure of models is very important in Modelica (see Fig. 34). For the model construction architecture, it is advisable to follow the rule stating that the structure of a component should always fit in a single screen. A complex tangle of connections is not the sign of a good design and calls for trouble.

The purpose of this chapter was not to describe the physiology of blood circulation. We just wanted to use the rather detailed description of the structure of some components to illustrate how acausal modelling tools allow the creation of richly hier-

archically structured, easily modifiable, “self-documenting” models.

When modelling extensive systems, such as the models of interconnected physiological regulations as a basis for medical simulators, the acausal modelling environment of the Modelica language is a great help.

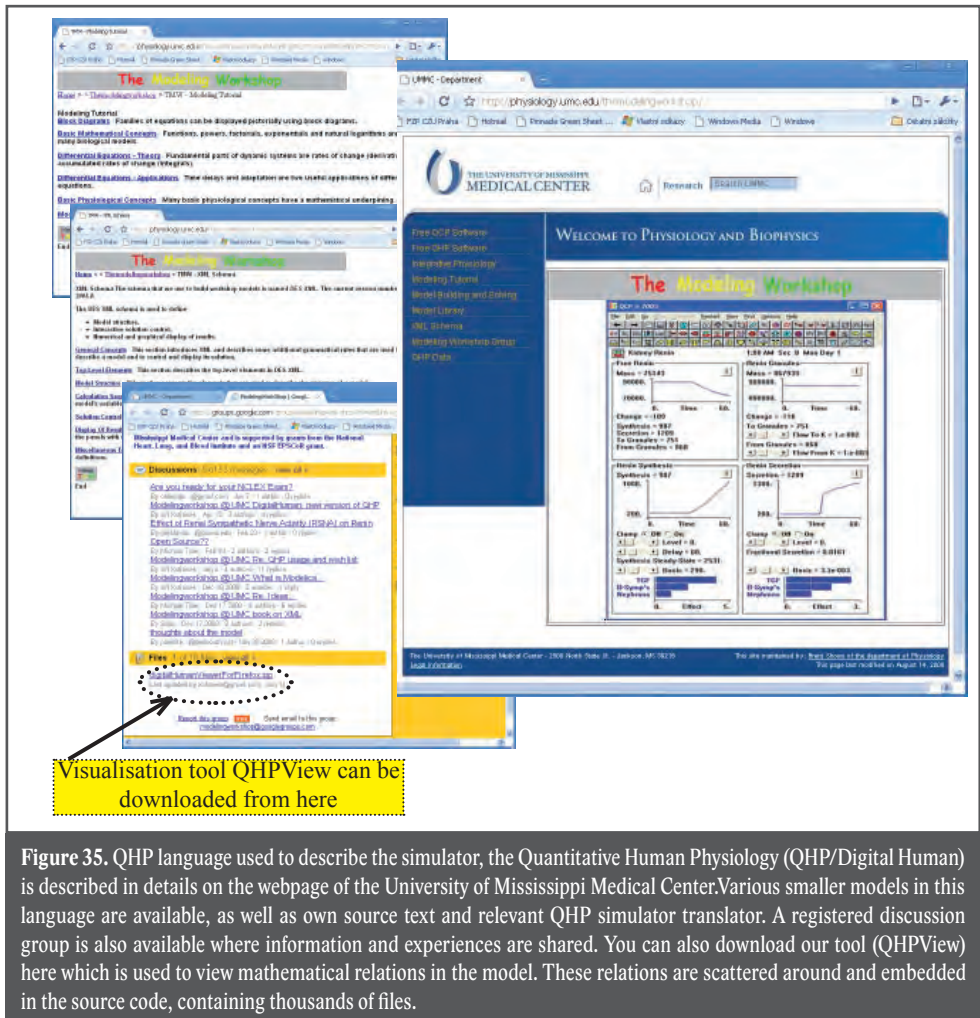
From Simulink to Modelica

It is simply amazing how fast the new Modelica simulation language adopted various commercial development environments. Only recently, just two commercial implementations of this language existed (*Dymola* from Dynasim and *MathModelica* from Mathcore), today (February 2010), the Modelica language is already used by simulation environments *LMS Imagine.Lab AmeSim* from the LMS company (<http://www.lmsintl.com>), *MapleSim* from Maplesoft (<http://www.maplesoft.com/>), *Mosilab* from the Fraunhofer company (<http://www.fraunhofer.de>) and *SimulationX* from ITI (<http://www.iti.de>).

Modelica is being used more and more in industrial applications. This modern simulation language is used by large corporations such as Siemens, ABB and EDF. Well-known automakers, such as AUDI, BMW, Daimler, Ford, Toyota, VW, use Modelica to design economic cars and air-conditioning units. The advancement of the development environments and technologies that use the Modelica language and the development of relevant application libraries is a part of the European research projects EUROSYSLIB, MODELISAR and OPENPROD financed by a total sum of EUR 54 million (see <http://www.modelica.org/>).

However, Modelica is still not used as much in biomedical applications.

The vast majority of biomedical simulation applications are still done in casual, block-oriented environments. These include referencing database development environments for biomedical models (such as the JSIM language <http://physiome.org/>



model/doku.php or CellML language
<http://www.cellml.org/>).

A frequently used environment in biology and medicine is Matlab/Simulink – monographs dedicated to biomedicine models are usually equipped with additional software used in this environment, but so far without the use of new acasual or non-casual Simulink libraries, such as Wallish et al. 2008; Logan & Wolesensky, 2009; Oomnes et al. 2009.

However, already in 2006, Cellier and Nebot pointed out the benefits of Modelica, when used for clear implementation of physiological systems descriptions and interpretations. The classic McLeod's circulation system model was implemented by PHYSBE (PHYSiological Simulation

Benchmark Experiment) (McLeod, 1966; McLeod, 1967; McLeod, 1970). The difference is clearly seen, if we compare the Cellier model implementation (Cellier & Nebot, 2006) with the freely downloadable version of the PHYSBE model implementation in Simulink <http://www.mathworks.com/products/demos/simulink/physbe/>. Haas and Burnhan, in their recently published monograph, pointed out the benefits and large potential of the Modelica language used for modeling medically adaptive regulatory systems (Haas & Burnham, 2008). The most recent, Brudgád a spol. publication (2009) talks about work on the implementation of the SBLM – <http://sbml.org/>), in the Modelica language. This would enable us in the future, to simply

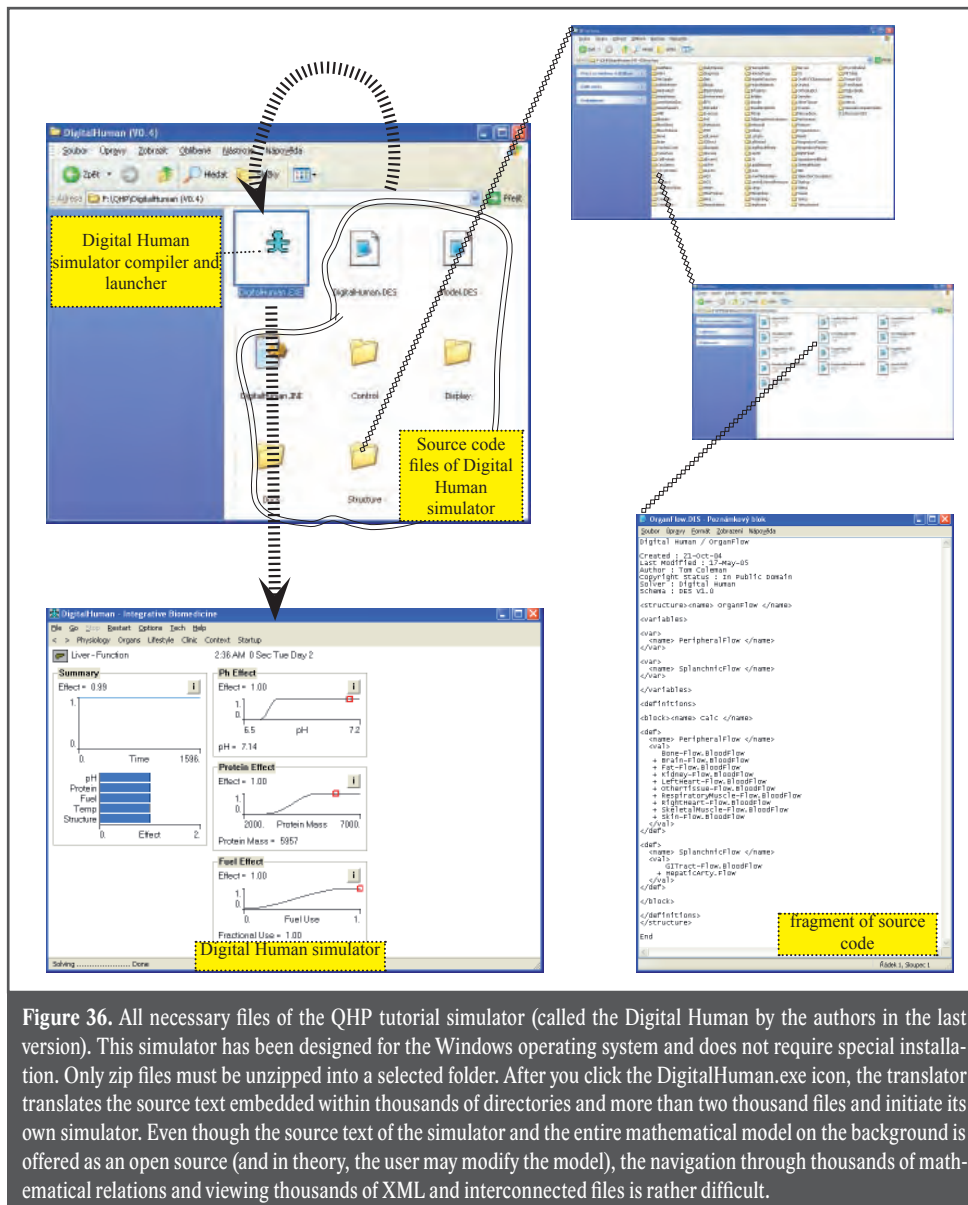
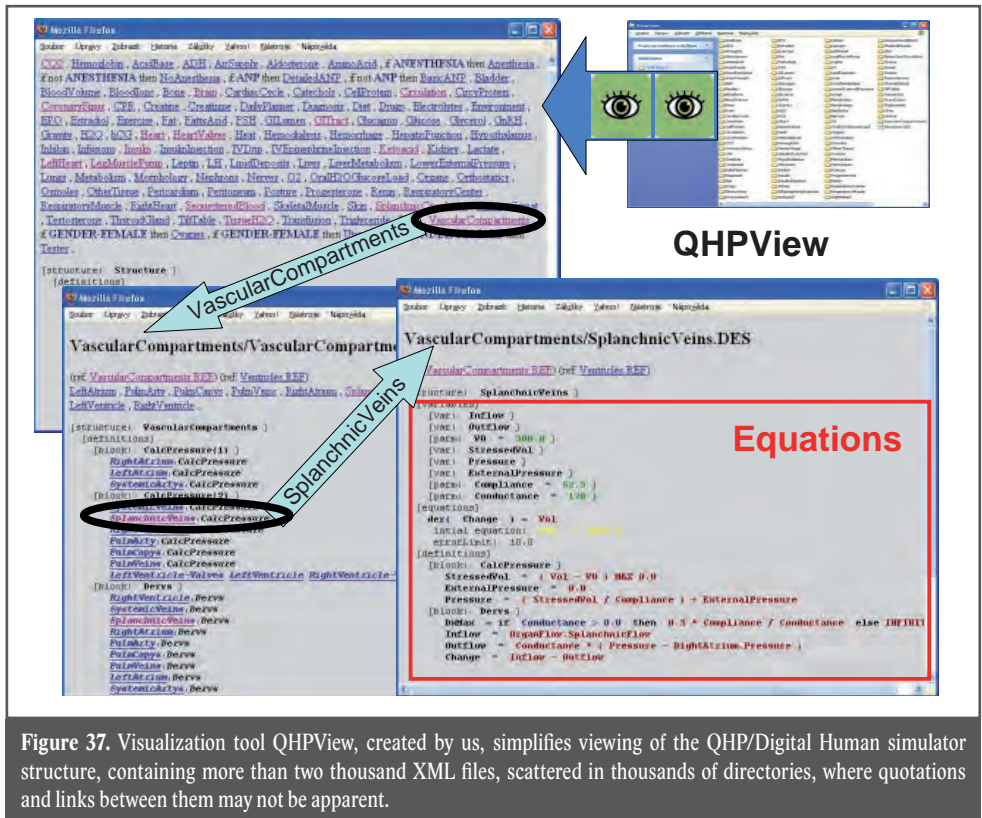


Figure 36. All necessary files of the QHP tutorial simulator (called the Digital Human by the authors in the last version). This simulator has been designed for the Windows operating system and does not require special installation. Only zip files must be unzipped into a selected folder. After you click the DigitalHuman.exe icon, the translator translates the source text embedded within thousands of directories and more than two thousand files and initiates its own simulator. Even though the source text of the simulator and the entire mathematical model on the background is offered as an open source (and in theory, the user may modify the model), the navigation through thousands of mathematical relations and viewing thousands of XML and interconnected files is rather difficult.

run models, whose structure is described in the SBLM language, on development platforms, based on the Modelica language. However, acasual models may be created in Simulink today as well, by using new acasual libraries (Simscape and others). We have been using Matlab and Simulink for years to create and develop models of physiological systems (Kofránek et al. 2001, 2002, 2007) and have also been developing the relevant application Simulink library – the Physiobrary [\[physiome.cz/simchips\]\(http://physiome.cz/simchips\)\). We have also developed the relevant software tools that simplify the transfer of models implemented in Simulink over to development environments \(ControlWeb and Microsoft .NET\), where we create our own tutorial and education simulators \(Kofránek et al. 2008\). Our development team gained priceless experience in previous years working with the Matlab/Simulink development environment made by the renown company MathWorks. On the other hand, we were also](http://</p>
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attracted by the new development environments using the Modelica language.

We were facing a decision whether to continue with the development process of physiological system models in Simulink (using new acasual libraries), or to make a radical decision and switch to the new Modelica language platform.

Our decision was affected by our efforts to implement a large model made by Guyton's coworkers and students (Hester et al. 2008). Their *Quantitative Human Physiology (QHP)* model is an extension of a tutorial simulator called the *Quantitative Circulatory Physiology (QCP)* (Abram et al. 2007).

The *QHP* model contains more than 4,000 variables and at the present time, it probably represents the largest and most extensive model of physiological regulations. It enables the user to simulate a wide range of pathological stages and statuses, including the effects of the relevant applied therapy.

Compared with the previous QCP simulator, whose mathematical background is hidden from the user in its source code written in C++, the *QHP* simulator uses a different approach. The QHP authors decided to separate the simulator implementation and description of the model quotations, in order to make the structure of the model more clear and apparent for the larger scientific community.

In 1985 the architect of this model, Thomas Coleman, had already created a special language used to write the model structure, as well as the element definitions into the simulator user interface. The language is based on modified XML notation. Model is then written by using XML files. A special convertor/decoder (DESolver) converts XML files into executable simulator code.

A detailed description of this language and DESolver converter, as well as the relevant educational tutorial, is freely accessible on the web page of the University of Mississippi (Fig. 35). The new QHP model is writ-

ten in the XML language as well. Its structure with all details may be found at (<http://physiology.umc.edu/themodelingworkshop>), published as an open source.

Therefore, the user can modify this model as he wishes. However, the model description has been divided into more than 2,833 XML files in 772 directories, from which the special solver creates and executes the simulator (Fig. 36).

The entire structure of the model and following links and references are not easily identifiable. That is why the international research and development team in its SAPHIR project (System Approach for Physiological Integration of Renal, cardiac and respiratory control) decided to use the old Guyton models from 1972 (Guyton, Coleman & Grander, 1972) and the Ikeda model from 1979 (Ikeda, Marumo & Shirsataka, 1979) for the creation of its new and extensive model of physiological functions instead of the freely available QHP model. The source codes of the QHP model appeared unclear or hard-to-understand to those involved in this project (Thomas et al. 2008).

The extensive QHP model is still at the testing, modification and expansion stage. **We have been able to agree on a long-term cooperation with** the main architect of this simulator, Thomas Coleman, as well as with other co-authors from the University of Mississippi, focusing on the future development of this model.

We have been able to create a **special software tool called QHPView** (Fig. 37), which is able to create a clear and legible overview of mathematical relations and connections from thousands of source codes.

We are offering this tool as an open source on the QHP web page at (<http://physiology.umc.edu/themodelingworkshop/>).

First, we tried to implement the QHP model in the Simulink environment.

The model contains a wide range of relations that offer solutions for implicit quotations. That is why the implementation of this block-oriented model (outputs from one

block are used as inputs for the next blocks) is very difficult and as the implementation got more and more complex, the transparency of this model went down quickly. The use of new acasual libraries in this complex model proved to be problematic and the transparency of the model improved only a little bit.

Therefore, we decided to stop using the Simulink implementation and began to implement the Modelica language (using the Dymola environment (<http://www.3ds.com/products/catia/portfolio/dymola>)).

Very quickly we discovered that the **implementation of a large and extensive model in Modelica is much more effective than using acasual libraries in Simulink**. When we compared the Simulink and Modelica implementations we also discovered a significant difference. Mainly due to the fact that the new acasual libraries are only acasual superstructure of Simulink and not an objectively oriented modeling language based on quotation, as the Modelica language is.

Therefore, if we compare the development environments based on the simulation language Modelica with the Matlab/Simulink development environments made by Mathworks, we may say the following:

- contrary to Simulink, the model implemented in Modelica much better reflects the essentials and base of the modeled reality and the **simulation modes are more clear, readable and less prone to errors**;
- **the object architecture in Modelica** enables the user to **build and tweak models with an hierarchical structure gradually, while using reusable element libraries**;
- contrary to Simulink (which is the industrial standard for Mathworks), Modelica is a **normalized programming language** and therefore, it may contain **various commercial and non-commercial developing environments competing between each other. This language is used** for specific problem solutions originating in various application fields

(for commercial and non-commercial specialized libraries);

- in Modelica it is possible to **combine casual (mostly signals) and acasual links non-invasively**; and unlike in Simulink, it is also possible, (within interconnected blocks) to create algebraic loops fairly easily – the assembler in Modelica contains symbolic manipulations on the background **and therefore the disconnection of algebraic loops is the task for the development environment and not for the programmer.**

The above specified reasons led us to use, as the **main implementation tool for the model creation, the Modelica** language and we also gradually stopped using the Matlab/Simulink environment, (Kofránek, Mateják, & Privitzer, 2008).

As far as the creation of application libraries and tools used in the Modelica development environments is concerned, we are involved in international cooperation.

The mutual efforts of 12 companies and 9 universities grouped together in the so-called Open Modelica Source Consortium, contributed to the development of the Open Modelica environment, distributable as an open source at (Open Modelica Source Consortium – see <http://www.ida.liu.se/labs/pelab/modelica/OpenSourceModelicaConsortium.html>). Our development team cooperates with Creative Connections s.r.o., which is a member of this consortium (see <http://www.creativeconnections.cz/>). We are currently developing a tool which would enable us to generate a source code/text in the C# language from a model created and debugged in Modelica.

QHP in a modeling coat

The implementation of the QHP model clearly shows the benefits of the model creation process when done in the Modelica language.

If we compare the complex structure of the QHP model by using the visualization option in QHPView (Fig. 37) with exam-

ples of implementations done in the simulation language Modelica, shown in previous pictures 26–34, we can see that the acasual implementation done in Modelica creates a transparent and legible model structure and therefore offers easier model modifications.

The QHP model implemented in Modelica is being currently **modified and extended.**

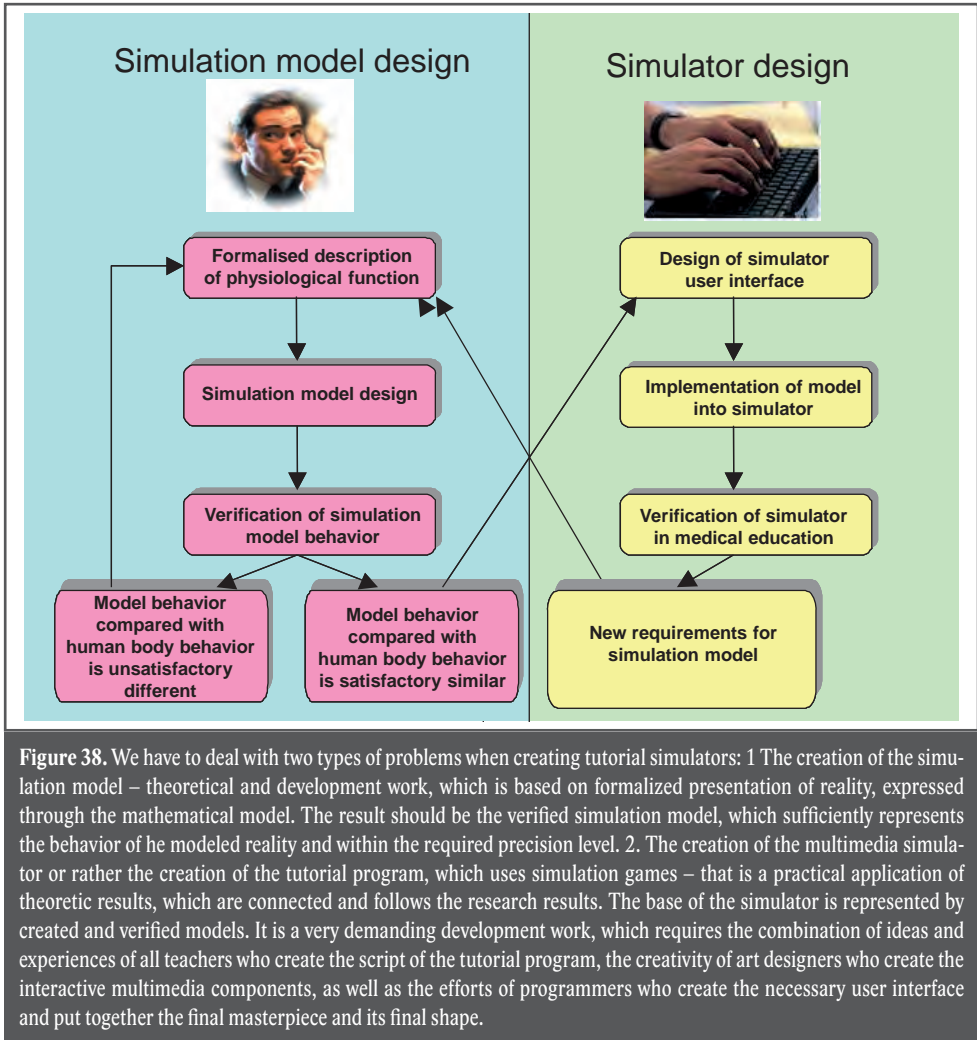
Modifications and extensions of QHP were partially taken from our original model Golem (Kofránek et al. 2001) and further modified according to newest findings and experiences.

Our modifications are mainly extensions, which improve the usability of the model during the modeling of difficult breakdowns in acidobasic (acid-based), ionic, volume and osmotic homeostasis of inner environments, which is very important for urgent medicinal statuses.

Our modification of the QHP model is based mainly on the **process of re-programming the acidobasicsubsystem balance**, which is based in the original QHP on the so-called Stewart acidobasic balance theory. Simply put, the so-called “modern approach“ of Stewart (Stewart, 1983) and his followers (e.g. Sirker et al. 2001; Fencel et al. 2000) explaining breakdowns in the acidobasic balance, uses mathematical relations calculating the concentration of hydrogen ions H^+ from partial pressure CO_2 in plasma (pCO_2), total concentration ($[Bu f_{tot}]$), weak (partially dissociated) acids ($[HBuf]$) and their base ($[Bu f^-]$, where $[Bu f_{tot}] = [Bu f^-] + [HBuf]$) and from the difference between the concentration of fully dissociated cations and fully dissociated anions in SID (strong ion difference):

$$[H^+] = \text{Function}(pCO_2, SID, Buftot)$$

The problem of this approach is that the precision of acidobasic calculations in the model depends on the precision of the SID calculation, that is the difference between the concentration of fully dissociated cations (that is mainly sodium and potassium)



and fully dissociated anions (mostly chlorides). Imprecision that is created during the modeling of sodium, potassium and chlorides intake and excretion are transferred and reflected by the imprecision in the modeling process of the acidobasic status.

Even though Coleman et al. (2008), significantly improved the modeling of reception and excretion of sodium, potassium and chlorides in kidneys in his QHP model, if we model a long-term status (when nothing is happening with the virtual patient), the virtual patient (in the current model version) has a tendency to fall into slight and steady metabolic acidosis after one month of the simulated time.

Our evaluative approach towards the modeling and evaluation of breakdowns in acidobasic balance (Kofránek, 1980; Kofránek et al. 2007; Kofránek, 2009) is based on the modeling and evaluation of two flows – the creation and excretion of CO₂ and the creation and excretion of strong acids, connected through the purification systems of each part of the bodily fluids. This approach, according to our opinion, better explains the physiological causality of acidobasic regulations, rather than direct modeling of acidobasic breakdowns through the balancing of accompanying electrolytes. Besides, the fidelity and truthfulness of the modeling process is getting better; mainly in mixed (acidobasic and electrolyte) breakdowns in inner environments.

Another important modification of the QHP, is the fact *that the model was extended by adding the dependency of the potassium flow on the intake of glucose as a result of insulin*, which enables us to model (besides other things), the influence of potassium solution infusions with insulin and glucoses, which are distributed in acute medicine for treating potassium depletions.

We have been using this “balancing and evaluation” approach towards the modeling of acidobasic balance in our old “Golem” simulator (Kofránek et al. 2001).

The extended QHP model serves as the base for the educational simulator “eGolem”, used in medical tutoring in clinical physiology of urgent statuses, which is being currently developed under the research project of MŠMT No. 2C067031. On the webpage of this project you may find the updated and current structure of our implementation of the QHP model (<http://patf-biokyb.lf1.cuni.cz/wiki/projekty/e-golem>).

From a model to the simulator

A simulation model, implemented in the most sophisticated development environment, cannot be used as an education aid alone. It is the implementation of the formalized description of the modeled reality that enables testing of the behavior of the mathematic model during various input values and the search for model quotations and parameters, which within the established precision range, can ensure the sufficient compatibility of the behavior of the model with the modeled system (model identification).

Even after this goal is reached, there is still a long road ahead from the identified model to the educational or tutorial simulator (see Fig. 38).

The creation of a multimedia educational and tutorial simulator is very demanding developmental work requiring a combination of the ideas and experiences of all the teachers who create the script of the tutorial

program, the creativity of art designers who create the interactive multimedia components, as well as the effort of programmers who create the necessary user interface and put together the final masterpiece and its final shape.

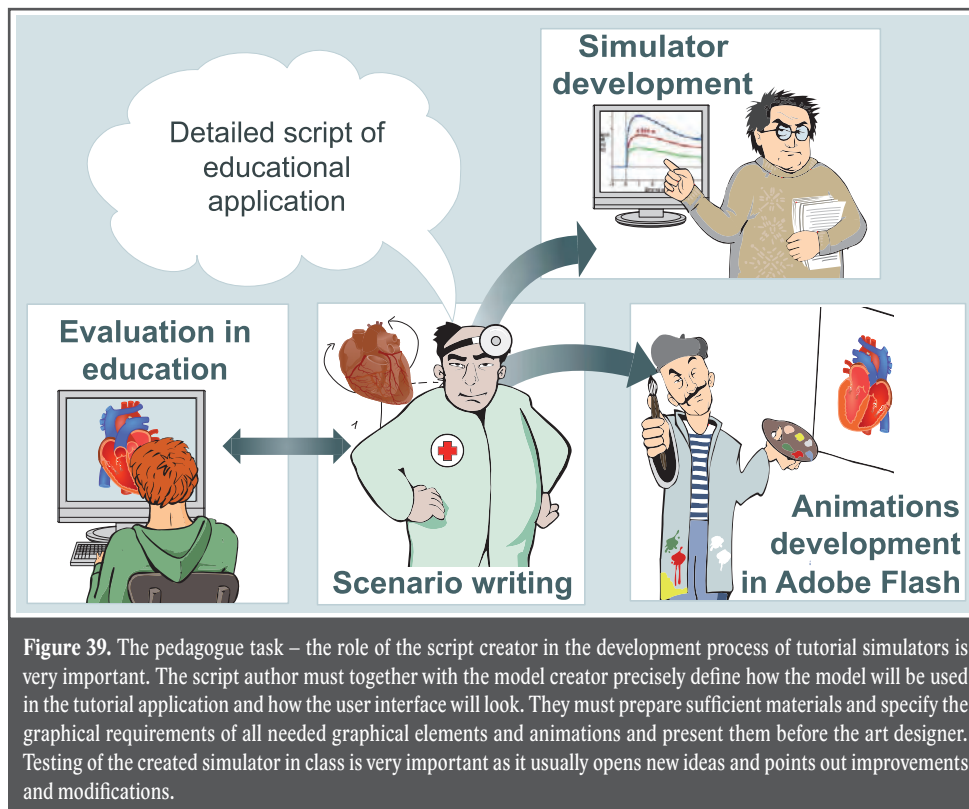
Thanks to advances in software technologies, we now have new tools available used not only for the creation of more effective simulation models but also tools that simplify the creation of own simulators equipped with attractive user interface graphics.

The skeleton of simulation application – the script

Simulation technologies have improved a great deal and have become more effective, while prices for equipment and software keep falling. The development of the Internet, virtual 3D environments such as the already mentioned software Second Life, or even the increasing range of medical simulators using robotized dummies, representing the patient, opened new options and potential for the medical education process. The use of a medical simulator during studies and education is becoming more and more popular and greatly utilized (mainly in the USA and Israel).

From the pedagogical point of view, an education process aided with a simulator is a very effective approach, but it is also a very demanding and challenging task for the teacher. Therefore, the most complex or sophisticated simulator equipped with the most attractive interface, is not guaranteed to be the most effective way of learning. Pedagogical efficiency depends on the *teacher*, who must have a *clear vision and know what is the most effective and most suitable way to use simulation model in the class*.

The more complex the simulator, the clearer the picture the teacher must have in his mind, being sure of how the class should look and what types of simulation games he wants to use. This is also confirmed by



our practical experiences with the use of complex simulators during classes (e.g. with Golem or QHP simulators). We have learned that a user interface offering many complex options or previews of hundreds of variables and parameters, takes away the concentration of students. Without clear pedagogical guidance pointing out what to look at or look for during the relevant simulation game while working with a complex simulator and without knowing how to interpret achieved results, the use of simulators is very ineffective.

However, from the pedagogical point of view, it is necessary to think in **advance about how** to use the simulator, before we actually begin with the creation. This is mostly true if we want to create multimedia and interactive educational programmes, available through the internet and using simulation games helping students understand and practice the subject better. The key for success is a **good script**.

The first person the success depends on, is an experienced teacher, who must have a very clear picture in his mind as to how he wants to explain the problem to his students, how the multimedia application should work, where they may be used and how to use the simulation model to help him explain the subject better.

The skeleton (the backbone) of educational application is the **script**. The base is usually studying text – script, chapter in a textbook, etc. However, during the creation process of multimedia tutorial application, we have to imagine how the tutorial program will be displayed on the screen, how each screen should follow after another (the sequence), what the graphical design will be like, where interactive elements will be placed, where the audio input may be, how each animation will look, where the simulation model will be inserted, where the knowledge test will be inserted, how it will be evaluated and what reactions on the test results will be required.

The final shape of graphical elements is completed by a professional art designer. Therefore, a *good communication between pedagogical expert/teacher – the script creator and the designer is necessary*. The teacher doesn't need to draw perfectly, but he has to have a clear and well-planned image in his mind and be able to explain to the designer what he wants from him. The biggest roadblock from the beginning was the constant need to redraw already drawn animations, usually due to the pedagogue's/teacher's fault, as he did not have a clear vision or image as to how to create the multimedia element in the script. Therefore, it is well-worth paying attention to careful planning and preparation before the actual beginning of the project (Fig. 39).

During the creation process of the tutorial application script, we found it very useful to use a procedure that is applied during a regular animation film making process – that is to draw (best together with an artist) a pictorial script, a so-called “Story Board” – an approximate sequence of each screen and then by using a regular text editor, write the relevant commentary (or a link reference pointing to the relevant part of the text) underneath.

Interactive multimedia programs are not scripts re-written and converted into a computer format. It is not a linear sequence of texts, audio sounds and moving pictures, as a typical animated movie is. The significant feature of an educational and tutorial program is *its interactivity* and the possibility of branching and mutually interconnecting individual parts. To remake or transform text and picture scripts into a branching script linked with hypertext links of the accompanying interactive program is not easy at all.

One of the methodological problems that we had to solve during the creation of our scripts for tutorial application, was the problem how to display the structure of the tutorial program in the script, including interpretations, interaction with the user, program, branching, etc.

The easiest way is to use a text or picture editor and by using regular block diagrams or structure diagrams, to describe the applicable branching, decision blocks, etc. with the relevant links on text pages and other relevant pictures stored in other files.

During the script writing, we also found using the abilities of modern text editors to create the required hypertext links helpful – which already gives the script some characteristics of its future interactivity.

We also tried using the *Adobe Captivate* tool to write the script for the tutorial application, see (<http://www.adobe.com/cz/products/captivate/>), which enabled us to create professional looking e-learning contents with advanced interactivity, without the need to have superb programming knowledge. We also found out that in order to write the script in the form of an interactively branched storyboard, this tool is too complicated. On the contrary. We learned that in order to share continuously created scripts between members of the development team, using simple tools is sufficient. To specify the requirements for the creation of the graphical elements given to designers, and for monitoring the results of their work and for monitoring other results, *Microsoft OneNote* was sufficient.

Modern interactive tutorial program is not an animated film converted into a computer form – the best advantage of interactivity offered by a computer, is the option to use *simulator*, which through the use of simulation games enables the user to explain the problem in virtual reality. The script of the tutorial program must take this advantage into consideration. The author must answer these following questions – what type of simulation experiments should be offered with the simulation model, what the user interface of the simulation game will be like, and finally what are the requirements for the simulation model running in the background.

Therefore, it is necessary for the “script-writer” to communicate with the model creator and to know the structure of the model,

so he may propose possible modifications and be able to explain the specifications that the model should have and comply with.

A key factor is also pedagogical experience. Sometimes elements or issues that appear simple and easy-to-follow during the development of tutorial application, may become difficult and hard-to-follow issues once integrated into the pedagogical process. Besides that, during the use of simulation games in the education process, the modification of either the user interface or the simulation model on the application background is necessary.

It is also necessary to create script proposals in close cooperation with *pedagogical experts and based on pedagogical experiences*. Therefore, we found it very helpful to first try the simulation application “on students” in class and based on the results, create the explanation text, modify the simulator and propose the final form of the user interface for the production version of the relevant internet-based e-learning application.

Muscles of tutorial simulation applications – interactive multimedia components

To create the user interface of the tutorial simulator, it is rather impressive to present the simulator as a set of moving pictures, controlled by the simulation model. The controlled animations may graphically represent the meaning of numeric values – e.g. a schematic picture of a blood vessel may be extended or compressed, the heart may pulse quicker or slower, the lungs may breath deeper, the arm of a measuring apparatus may move and display a value of some variables of the model read from the simulation model running on the background, etc. On the other hand, we may enter various inputs into the simulation model (using various press buttons, buttons, levers and so on).

The graphic look/design is important as well, as it may determine how the tutorial

and educational application will be accepted by potential users.

To achieve a professional final look of the tutorial simulator, it is necessary to have an *artist create the animations* – the results are much better than if animations are created by a programmer, even with graphical talent. However, the art designer must be able to use interactive graphics tools. But art designers with these skills are very hard to find and artists who are able to work with these tools are in demand and are usually highly paid members of professional teams that produce computer games, web portals and multimedia commercials and applications, etc.

To accomplish this, we had to shift a *great deal of our attention to training and schooling* art designers in order to make sure that they know how to use these tools. Therefore, we began to work closely with the *Václav Hollar College of Arts*, where we opened an interactive graphics laboratory, as a detached workplace of the Charles University.

We spent a great amount of time trying to teach professional artists to work with interactive animation development tools, such as Adobe Flash, Microsoft Expression Blend, etc., or to work with 3D graphics development tools (e.g. Adobe Premiere), then to integrate it all into applications accessible through the internet (e.g. Adobe Flex) and finally teach them about the basis of program controlled interactive animations and about the creation of interactive web pages. Our efforts were rewarded. Graphic artists stopped being shy in front of the computer and quickly understood that “a digital brush” is just another creative tool, giving them a way to express themselves and that mastering a digital brush gives them an opportunity to succeed in the professional field.

We have also helped with the establishment of a “higher professional school”, where interactive graphics are taught in three-year courses. Workers of our Bio-cybernetics department and workers of the compu-

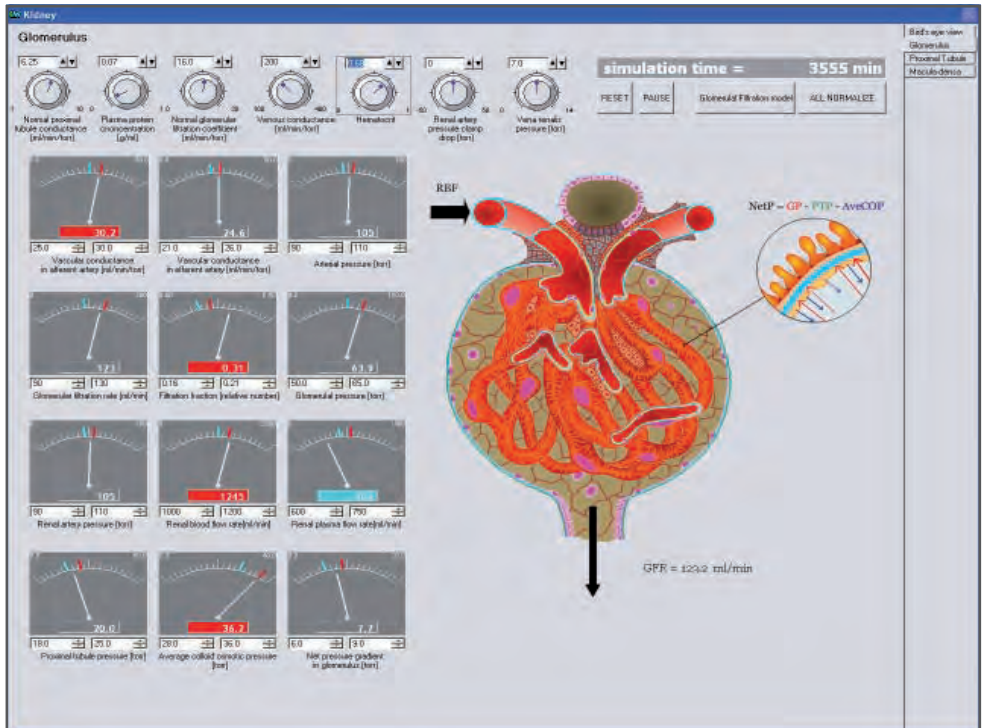


Figure 40. Visual interface of tutorial simulator demonstrating kidney functions, created in the ControlWeb environment. Outputs from the model are displayed on arm-gauges and at the same time they affect the shape of the inserted animated picture of the kidney glomeruli (artery diameters, arrow thickness and numeric value, etc.), created in Adobe Flash.

ter support system classes, also teach here, (<http://www.hollarka.cz/>).

On one side, the artist must work with the *pedagogue, who creates the script of the tutorial application and also with the programmer* who makes sure that interactive animations behave as required (e.g. he interconnects interactive animations with the simulation model). Therefore, even the art designer must have basic knowledge of programming, so he may communicate with the programmer effectively.

In the past, we have used the *Golem simulator* for the simulator interface, (Kofránek et al. 2001) and the *ControlWeb software environment*, originally designed for visualization and control of industrial processes (see <http://www.mii.cz/cat?id=1&lang=409>), which offers a wide range of preset elements – virtual instruments, which enabled us to create the user interface quickly and comfortably. However the quickly and comfortably created simula-

tor looked more like a technological control panel than an interactive picture from a medical book (see Fig. 40).

When professional artists joined our development team, the potential of visualization improved significantly and we were no longer limited by the range of preset elements in tutorial programmes. We were able to create any shape of animated components, which we could connect with the simulation model and control them by the output or input values of the simulation model.

To create interactive multimedia components, connectable with the simulation model on the background, we use two tools (Fig. 41):

- The first one is *Adobe Flash*, where we can create animated interactive components, which may be programmed (and may be connected with the simulation model in our applications). The created components may be easily

played back in the internet browser (if the freely available Adobe Flash Player is installed) and on various operation system platforms. Also, less demanding numerical simulators, easily playable directly from the web page browser, may be created in Flash. We also used Flash components as the visual interface, communicating with the simulator core (through the ActiveX component) which were created in the ControlWeb and .NET environments.

- The second tool that we have started to use recently for the creation of simulator graphical components is the **Microsoft Expression Blend** development environment. This environment, while using the Microsoft .NET development environment, enables us to create applications that may be played or run directly in the internet browser, providing that the **Microsoft Silverlight** add-on is installed. The Microsoft Silverlight platform is capable of running numerically demanding applications with an interactive multimedia interface. This new Microsoft platform enables the user to distribute numerically demanding simulators over the internet, playable directly from the internet browser.

Adobe Flash Animation brush designed for artists

Flash has been developed over a long period of time. First, it was made by Macromedia and used only for the creation of animated pictures. At that time, we were creating tutorial animations in a different product, the Macromedia – Director (Fig. 42), which enabled us to control animations through scripts (Kofránek & Svačina, 2001).

During that time, the option to control animations through scripts became available for Flash as well, as the syntax got gradually richer and better. Starting with version 7 (sold and known as Macromedia Flash MX 2004), the Flash environment already contained an object control language (Action-

Script) with syntax very similar to Java, which offers rather sophisticated and comfortable control of the visual interactive elements.

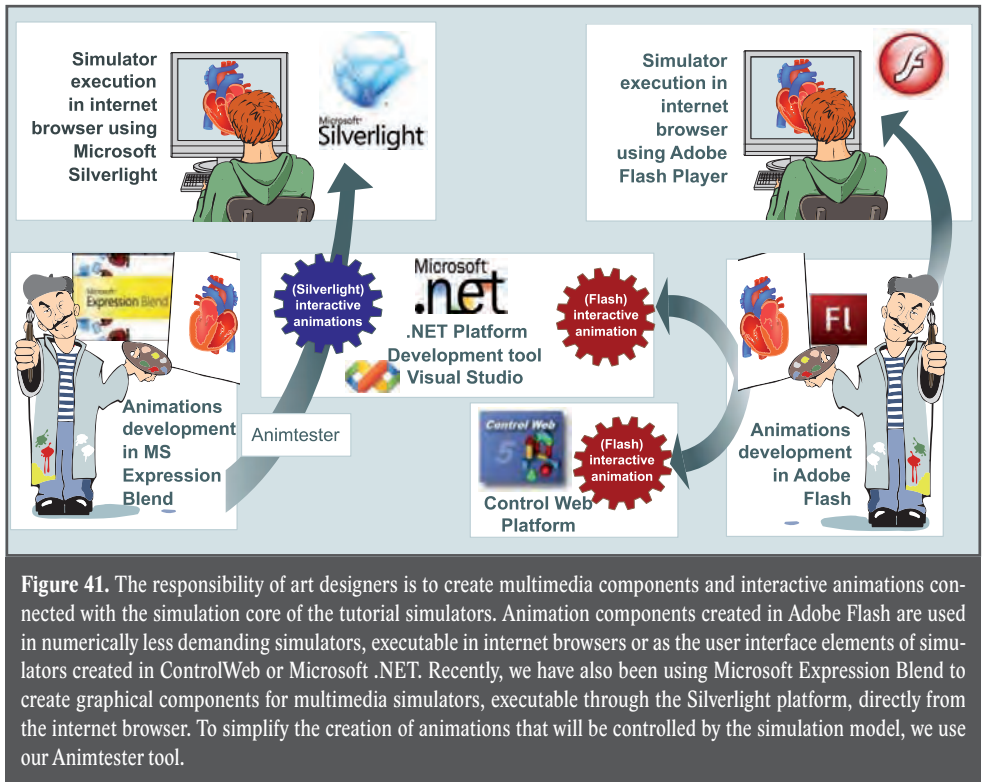
The huge success of Macromedia Flash is partly because its creators were able to successfully define an interface for artists **and art designers** (enabling them to create basic animation elements), as well as for **programmers**, who by using the above-mentioned objective language can “vitalize” and give interactivity to these components.

The basic component of the Flash application is a film/movie. Film may be divided into each scene, which may be played back in a programmed sequence or at random. Scenes are composed of sequences, which contain individual frames. Films may be linked – from each movie you may call a link from another movie and initiate playback of the movie. This is very useful in internet applications, when the first part of the animation is played and the other part of the movie is being downloaded in the background.

The creation of computer animations is based on the creation of classical animated films, where each frame is drawn on transparent foils and stocked above each other. Some frames may not be completely redrawn and they are only moved (e.g. the background is moved), while other frames must be redrawn completely or partially (e.g. just the moving figure, etc.) in order to create animation – moving pictures.

In Flash, (Fig. 43) each scene consists of several layers, which works similarly as the foils used in animated films.

Each frame or scene has several layers, where each picture element is stored. These visual elements may be drawn in each layer separately – Flash includes a powerful tool for the creation of vector pictures (vector pictures may also be imported from other external painting or drawing applications). Or the picture may be selected from a library and the required shape created. However, the sample shape may not only be represented by a still picture. You may select



a clip from a movie, (MovieClip), which in reality is an instant classic of a previously created film. For example, if we want to create a picture of a plane, we can select a rotating propeller from a library and insert it into one of the layers, as one element of the picture. A special type of movie clips are buttons. The shape and graphics may be designed (when the cursor is moved over the button or when the button is pressed), as well as the button action, behavior and function. The movie clip may have a rather complex structural hierarchy – the film that creates the clip may contain instances from other clips. For example, a MovieClip of a car may contain movie clips of spinning wheels. Each instance of a MovieClip has its parameters (coordinates specifying its location on the screen, size, colors, transparency, etc.), which may be changed dynamically in the program. Besides that, the MovieClip class offers many methods that may be used (e.g. a method which detects the collision between two instances of a MovieClip, etc.).

During the creation of a MovieClip we can also program specific methods, which may be recalled from its instances. We may also program the complex behavior of visual components. It is rather easy to create special MovieClips as real components and then set their parameters and properties in a special component editor and recall their methods while the clip is running. This enables manufactures to create (and distribute and sell) various visual (and non-visual) components and helped with the introduction of Flash in the artistic community.

The graphical and the programming part of the movie is created in the development environment. Then it may be tested or translated into a sub-language (in .swf format), which may be interpreted by using the freely available and downloadable interpreter (the so-called Flash player) and played back as an individually executable animation or it may be viewed in the internet browser (see Fig. 41).

Besides that, the created .swf file may be interpreted by using the special ActiveX

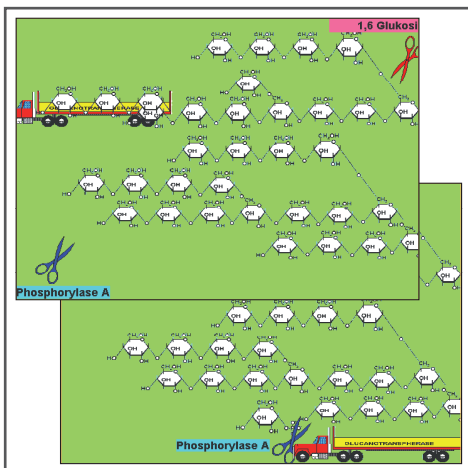


Figure 42. A multimedia tutorial program with interactive graphical animations created in Macromedia Director in 2000. At that time, Director offered stronger support for interactive programming than Flash. But Flash soon overcame this handicap and offered richer options of interactive controls than Director. Besides that, Flash offered a more intuitive user interface, resembling tools used for creation of animated films and became very popular among art designers. Therefore, we stopped using Director in 2000 and began using Flash for interactive animations.

component, which may be integrated into another program – e.g. into an application created in ControlWeb or in Microsoft Visual Studio. The important thing is that this component may exchange messages with the application, enabling us to comfortably control the behavior of the interactive application through another application. The application may also receive messages from the interactive animation, describing or referring to the user action/intervention. The huge success of Flash caused that the Adobe company bought Macromedia and Flash became one of the integral parts in portfolios containing computer graphic tools made by this manufacturer.

Today, Flash components may be used in so-called RIA formats (Rich Internet Application) – a new generation of multiplatform web applications with superb complex user interface design, created with **Adobe Flex** or as a desktop application created with **Adobe Air**.

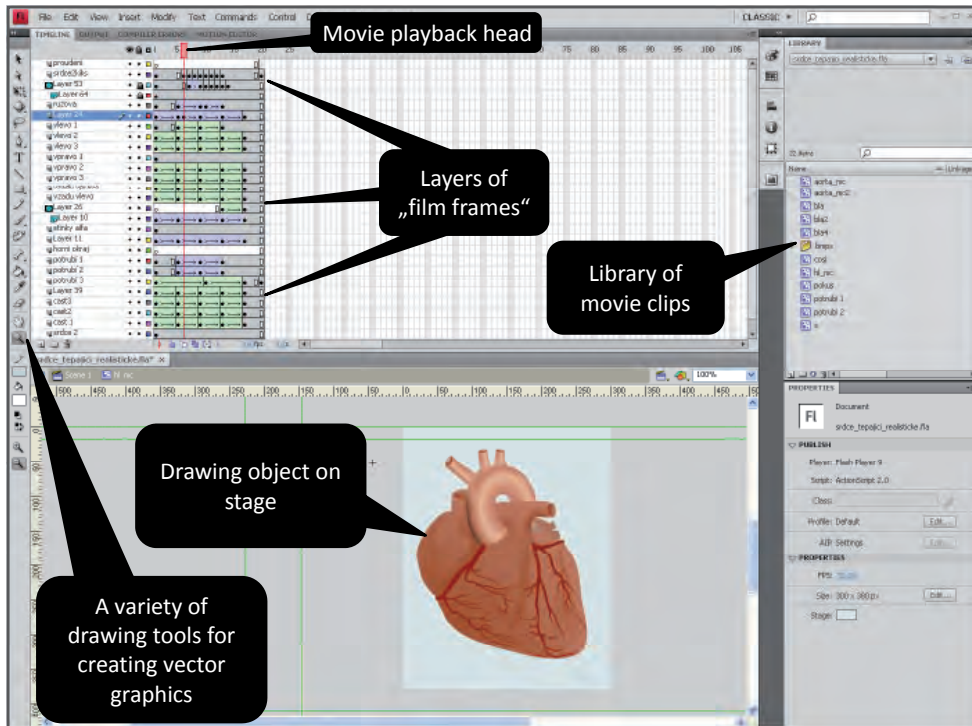


Figure 43. Adobe Flash environment offers tools for vector picture painting. Each layer of movie frames (as seen on the picture) may be also inserted with a sample of movie clip, selected from a library. The behavior of each visual and non-visual component may be programmed in a special programming window.

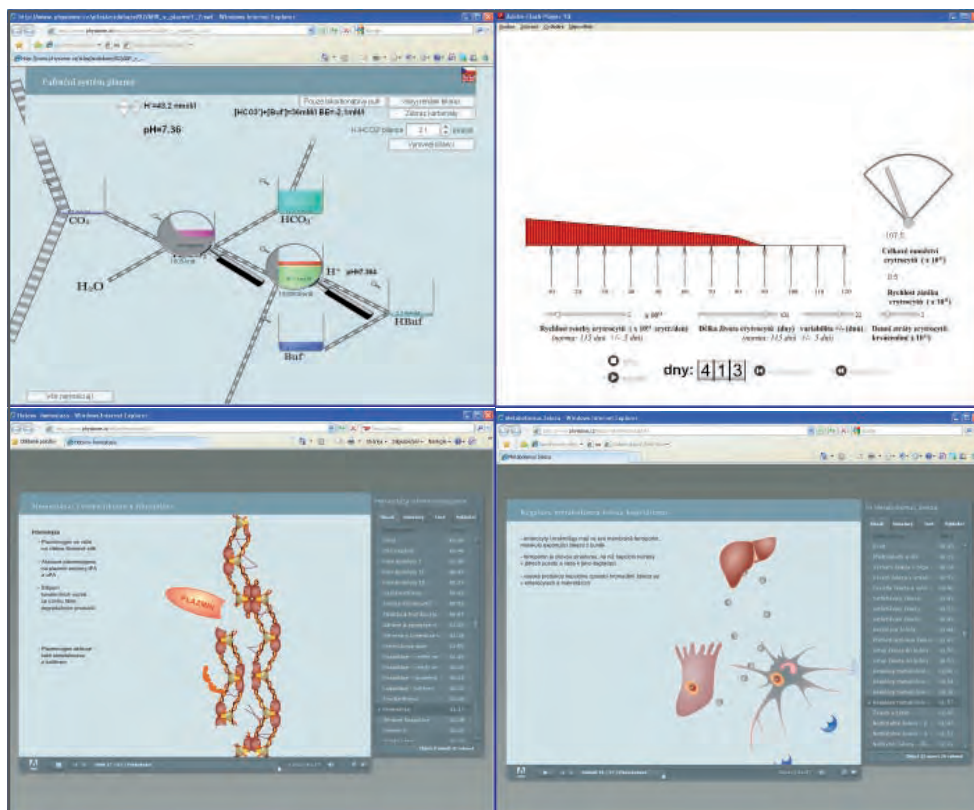


Figure 44. The Adobe Flash environment may be used for the implementation of simulators executable directly from the internet browser e.g. the model of acidobasic plasma balance or the anaemia model. Until now, Flash was also the main implementation environment for audio lessons and chapters in our internet Atlas of physiology and pathology. Lessons and lectures contain animations fully synchronized with sounds. Using a slider you may stop or move the lesson back and forth, while the animation is fully synchronized.

The speed of the .swf file interpreter (Flash player) has improved and the ActionScript language can now be used to create the simulation core of tutorial simulators. The advantage of Flash tutorial and education applications (which may contain complex RIA applications, compiled in the Adobe Flex environment) is that these applications may be executed directly from the internet browser (providing that the relevant plug-in is installed) and run on all platforms.

We have created some tutorial simulators and multimedia interactive applications with simulation games in this environment (see Fig. 44).

In 2004, using Flash, we created (besides other applications) an interactive multimedia tutorial application called “Music as seen by physics and physiology. Tun-

ing/tweaking Theory” (<http://patf-biokyb.lf1.cuni.cz/~obdrzalek/ladeni.htm>) for which we have received the “TECHFILM Laureate” reward at the TechFilm festival, (Obdržálek & Kofránek, 2004). Using Flash, we have also created a twenty-minute film called “The Historical Meeting” (Kofránek, 2006), dedicated to the history of relationship between the Czech Republic and Sweden during the Thirty-year war. Our Atlas of physiology and pathology was also implemented using the Flash platform (see http://www.physiome.cz/atlas/index_en.html).

However, the Flash player environment is still an environment based on the interpretation of .swf flash files. For numerically demanding calculation used in more complex simulators we encounter certain

performance barriers. For more complex simulators, the Adobe Flash environment is (so far) insufficient.

More complex simulators are created in the **.NET environment** (and in the past they were created in **ControlWeb**). Flash components are integrated into these simulators by using the ActiveX component. But to bridge between the two different “worlds” of Adobe Flash and .NET, and to make sure that both operate in unison, hard programming work is involved.

Microsoft Expression Blend – a tool for the creation of „graphical puppets“ for simulators

However, the Microsoft .NET platform may be used directly for graphical applications (without the need to interconnect Adobe Flash components). Thanks to **WPF technology – Windows Presentation Foundation** (Sells & Griffins, 2007) we can use the .NET platform to create complex graphic components containing animations, vector graphics, 3D elements, etc. Graphical elements may be created similarly as in Adobe Flash but with potentially better options for controlling their behavior, than in Adobe Flash. Besides that, Microsoft swiftly reacted to the widely spread addition of Adobe Flash internet simulators and created its own **Silverlight** platform, which similarly as Flash Player, is capable of running complex appli-

cations combining text, vector and bitmap graphics, animations and videos from internet browser. The application runs as the primary application in the internet browser without the need to install it (the only required application to be installed is the Silverlight plug-in). Therefore, by installing a small component, Silverlight enables the user to interactively control applications in the majority of web browsers (Internet Explorer, Firefox, Safari) and on various hardware and software platforms. Now Windows and Mac operational systems are directly supported for the most popular browsers and fully compatible open source implementation is under development for Linux OS. Applications created for this platform use a significant part of the .NET framework, which is a part of the plug-in (and therefore these applications may handle quite complex calculations).

Silverlight is a platform which is capable of distributing **simulators that run directly in the internet browser** via the internet (and even on **computers with various operating systems** – the only requirement is installing the relevant add-on (plug-in)).

The important parameter of **Silverlight** is that it **includes native support of animations** (Little, Beres, Hinkson, Rader & Croney, 2009). Therefore, animations are part of the application and it is not necessary to use an additional platform such as Adobe Flash for graphic layers.

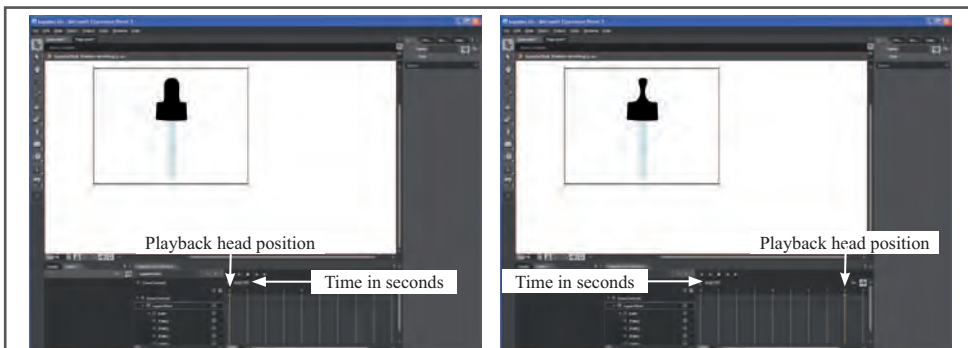


Figure 45. Key animation frames created in Microsoft Expression Blend are placed directly on the time axis. This makes the synchronization of animations with the audio track easier.

animations, controlled from outside, by using control elements (buttons and sliders). When the application is generated, the art designer and the author of the tutorial application (the pedagogue) may check and verify how the animated component will behave.

This enable the art designer to be shielded from the programming work details. And similarly, the author of the proposal of the tutorial application doesn't need to focus on the implementation details of the graphical proposal and may communicate with the art designer easier and thus reach his vision and goal quicker.

The task of the programmer implementing his own simulator is to interconnect the generated graphical object with the simulation model on the background. The animated "puppets" created in this way and controlled via values that control their shape, may be *directly connected to model outputs, without the need to add another programming „middle“/sub-layer for data propagation*, as is necessary in *Flash animations*.

The use of graphical options in the *Silverlight platform* replaces and compensates greatly for the original approach using animations based on the Adobe Flash platform. Therefore, during the creation of animations as a visual interface for simulators, we *do not need the Adobe Flash platform, which may be fully replaced with the new animation tools from Microsoft*.

The brain of the tutorial and education application – the simulation model

Implementation of simulation models in the education and tutorial program is not a simple issue.

To create simulation models, we use special development tools, designed for tweaking, tuning and verification of simulation models (*Matlab/Simulink* or acasual development using the *Modelica* language), which we discussed in previous chapters.

Debugged *models* must be *converted* from the development environment where they were created, debugged and verified *into the environment where the tutorial simulator itself is being created*.

This may be done manually for simple models – as is often done in purely Flash tutorial simulators, where the development environment for the creation of simulators is Adobe Flash only.

However, for more complex models we created software tools which automate this work for us (see Fig. 49). In the Golem simulator, implemented in the ControlWeb environment, the model was represented as a controller of virtual measuring/control card (see Fig. 50). To automate the transfer or conversion of the simulation model from Matlab/Simulink we have created a generator, which creates the controller source text in the C language directly from the Simulink model. (Kofránek et al. 2002).

And to simplify the creation of simulators done in Visual Studio .NET (that is to eliminate "manual" programming of the debugged simulation model in Visual Studio .NET) we developed a special software tool (Kofránek et al. 2005; Stodulka et al. 2007), which automatically generates from the Simulink simulation model in a component form useable in the .NET environment. The output in Modelica is the generated simulator program in C++. If we are ok with a simulator that needs to always be installed in the client computer then the program in C++ is sufficient. But, if we want to make use of the new options available in the .NET environment, which enables the user to create applications in Silverlight and run in the internet browser, then we have to create a tool which will generate the model source text in C# from Modelica, which is also our current goal at the international Open Modelica Source Consortium as mentioned earlier – (see <http://www.ida.liu.se/labs/pelab/modelica/OpenSourceModelicaConsortium.html>).

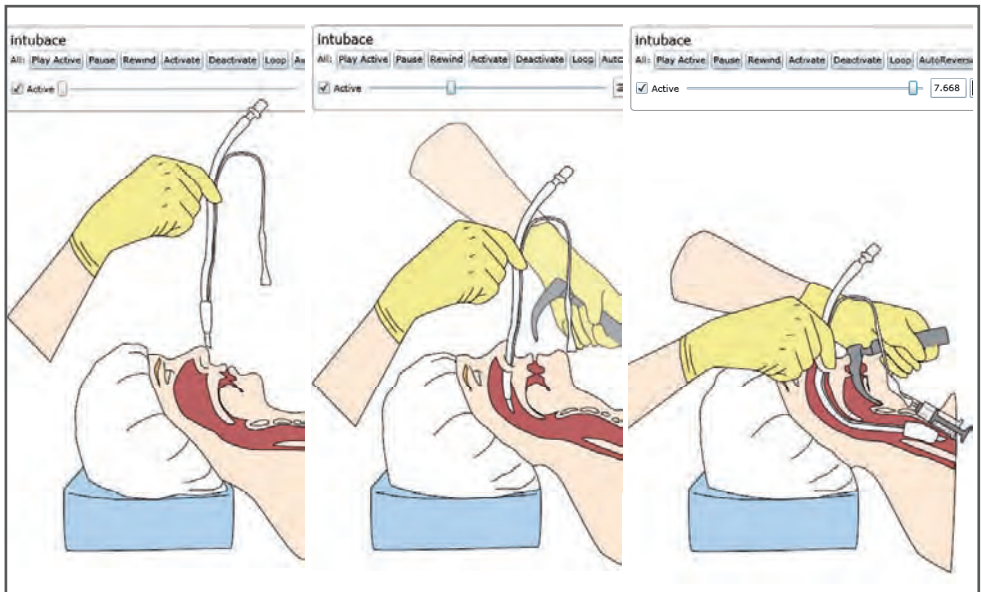


Figure 47. Patient intubation. An example of complex animation created in Expression Blend, while using Animtester.

The body of the tutorial simulator – installed program or web application

The creation of a tutorial application is quite demanding programming work, based on the creation of the simulation core of the developed application (unless this core was already automatically generated from the applicable simulation development tool) and its interconnection with graphical elements of the visual user interface (see Fig. 51).

For simple tutorial applications with simple models we can use Flash player with the ActionScript language, which we use to program the simulator itself and the entire application may be run in the internet browser.

However, this is not enough for more complex applications.

In the past, we were creating simulators in the ControlWeb development environment, made by the Czech company Moravské přístroje (Kofránek et al. 2001; Kofranek et al 2002). The created application had to be installed in the client computer or (in case of web-distributed applications), at least the

ControlWeb runtime environment had to be installed.

For the development of simulators today, we use the Microsoft .NET platform and for programming work, the Microsoft Visual Studio .NET programming environment, which offers great options for programming. We can also use the graphical component of the user interface created in Adobe Flash, which we can interconnect with (via ActiveX) the core of the simulator, which is represented by the simulation model and *graphical components may then behave as puppets controlled by the simulation model*. This method was used during the realization of our Atlas of physiology and pathology, dedicated to the basic dynamic properties of physiological regulatory systems – <http://physiome.cz/atlas/sim/RegulateSys/> or the blood gas transfer tutorial simulator – http://physiome.cz/atlas/sim/BloodyMary_cs/.

The disadvantage of this approach is the necessity to install the program (offered through the internet interface) into the client computer. In such scenario the client needs to have the relevant installation rights applicable to the computer that he works

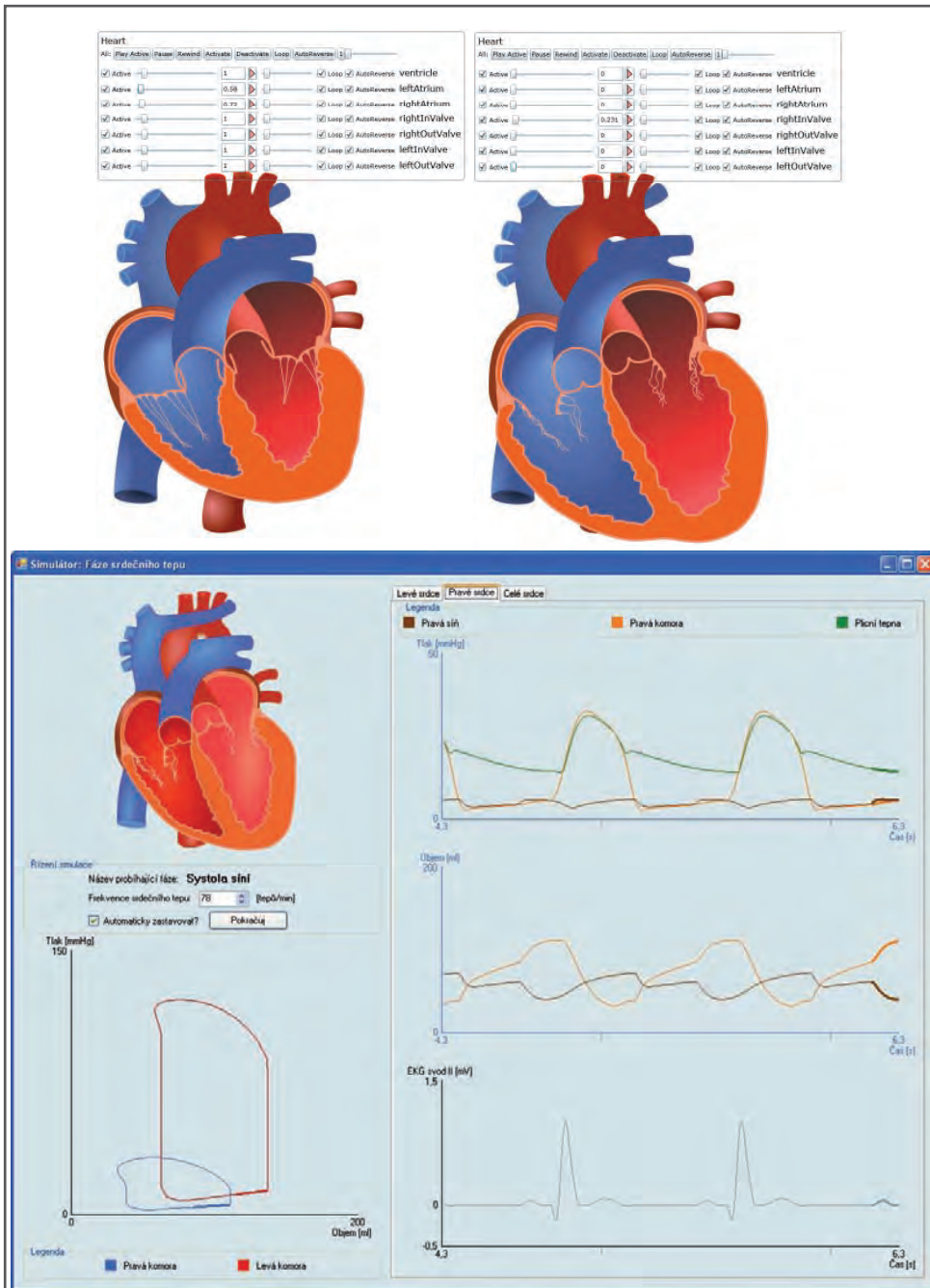


Figure 48. Animation of a beating heart. Outputs from the model affect the phases of the heart pulse, opening and closing of cardiac valves, etc. Auxiliary Animatester control elements are above the animation and enable the graphic designer to set and tweak each sub-animation. The graphical designer is completely shielded from the programming process. In the final simulator, the „control ropes and levers“ are pulled by the simulation model, programmed on the background.

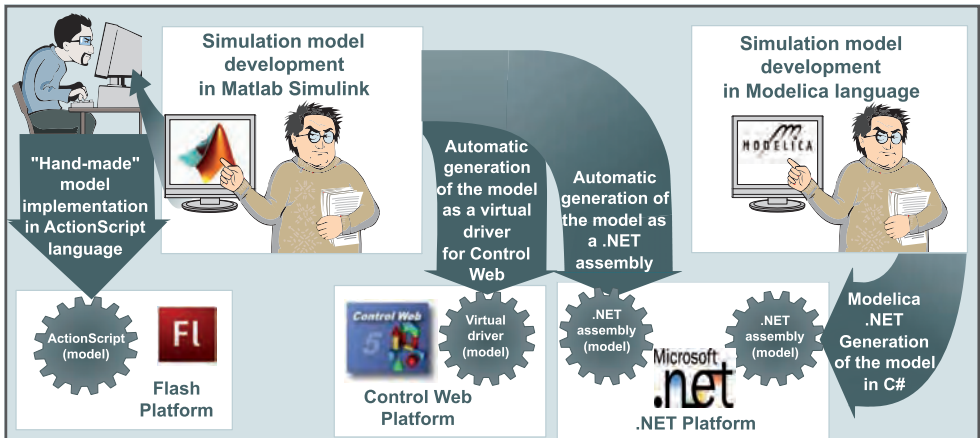


Figure 49. We have been using Matlab/Simulink for the development of simulation models but recently we began using the Modelica environment (e.g. Dymola or MathModelica). The identified simulation model may be manually re-written for the environment where the simulator will be created. This is possible only for simple simulators created in Adobe Flash or in Adobe Flex). For more complicated simulators created in .NET (or previously in ControlWeb) we have created special tools that automatically generate the simulation core from the Simulink model. At present, we are in the process of creating a tool for Modelica, which will be capable of generating the model in the C# language, which will enable us to create web simulators executable directly from the internet browser (using Silverlight).

on. However, this is not the case in computer classes, where computers are protected from the installation of unwanted software and the user must first ask the administrator for permission to install the educational program.

Therefore, it is desirable to be able *to run and control even complex models directly from the web browser*. This is possible if the entire simulator can be executed in the *Silverlight* environment, that is, if the entire core has been created in the form of a control code designed to be used in the .NET environment (in .NET assembly), and the

graphic components are created in the Microsoft Expression Blend environment.

Simulator structure – MVC architecture

If the architecture is more complex, the logic used to interconnect the visual user interface with the simulation model may be quite difficult. Therefore, it is better to insert a control layer between the visual element layer and the simulation model layer, which solves the communication logic between the user interface and the model

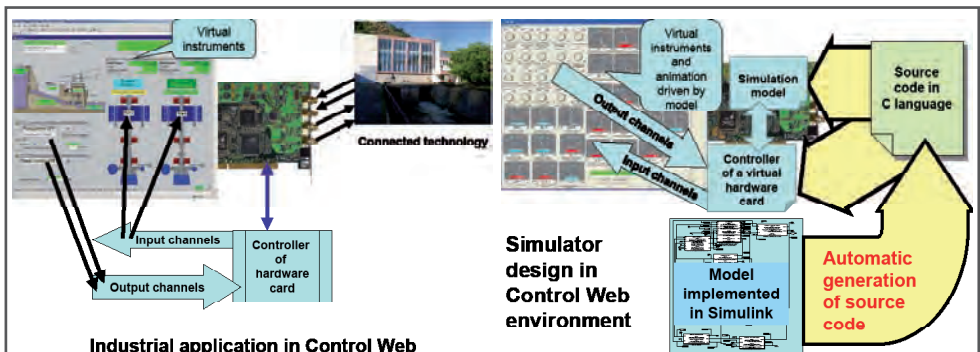


Figure 50. Simulator development in the Control Web environment, originally designed for visualization of control and measurement industrial applications. The simulation model is programmed as a software controller of a (non-existent) virtual card, and the application under development in Control Web communicates with the model as if it was a technological device.

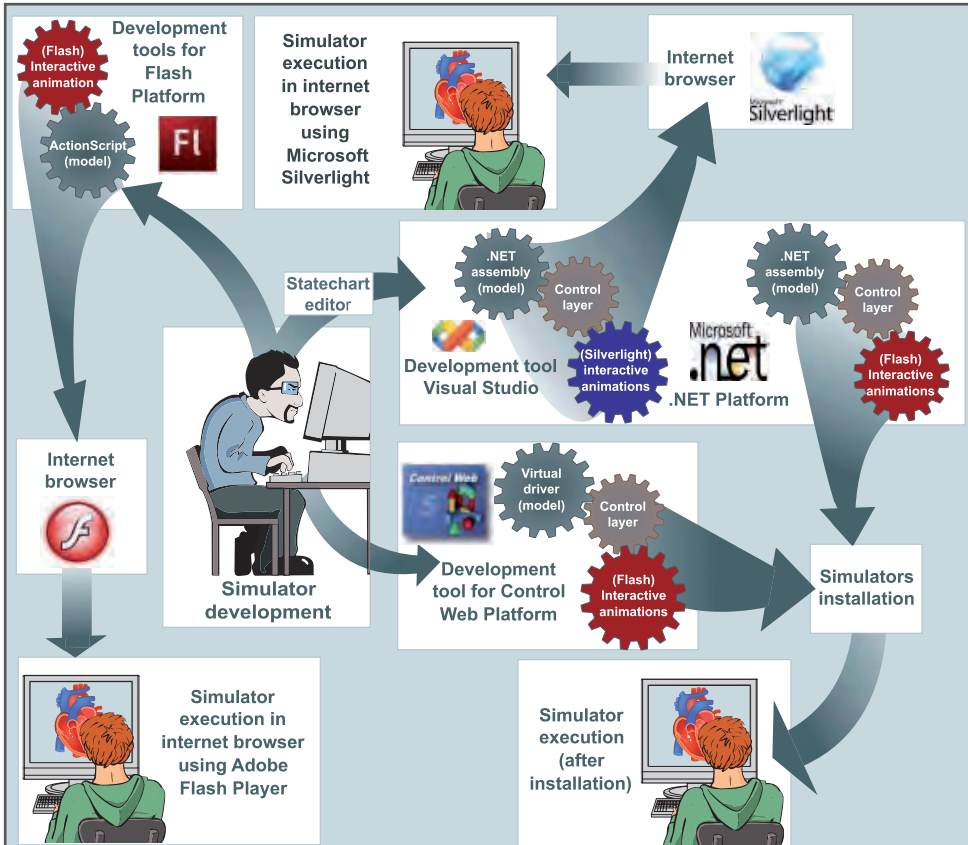


Figure 51. The programmer is responsible for the development of his own tutorial simulator. Based on the knowledge of the structure of the identified simulation model, we may use Adobe Flash or Adobe Flex to program the simulation core and the relevant user interface of the tutorial simulator, which uses Flash animations. The entire application may then be distributed via the internet and run/played in the internet browser, using Flash player. However, more complex simulators are created in the .NET environment (in the past we were also creating simulators in ControlWeb). The simulator creation process assumes that the programmer will interconnect animations with the simulation component of the model (realized as .NET assembly). To make this programming process easier (and to create the interconnecting control layer) we have created a tool called Statechart Editor, which is based on the utilization of the hierarchy of status instruments. Simulators that use flash animations (interconnected with surroundings via ActiveX) require installation of the created application in the client computer. If we create animation in Microsoft Expression Blend, then we can create applications that are executable in the internet browser, with the Silverlight add-on. Using this method, we may create quite complex and numerically demanding tutorial simulators, distributed as web applications and executable in the internet browser, installed in the client computer.

and where the relevant context is stored. In literature (Collins, 1995; Leff & Rayfield, 2007) we may find the so-called MVC architecture (Model – View – Controller). This setup is necessary mainly for more complex models and simulators, whose user interface is represented by many virtual instruments displayed on several interconnected screens. The advantages of this setup are seen mainly when applying model or user interface modifications (Fig. 52).

When designing the control layer, which connects the simulation model layer with the user interface, we found using interconnected status instruments very useful, which are able to memorize the relevant context of the model, as well as the context of the user interface.

For this reason, we have created a special software status tool called *Statechart Editor*, which enables us to visually design the interconnected status instruments, inter-

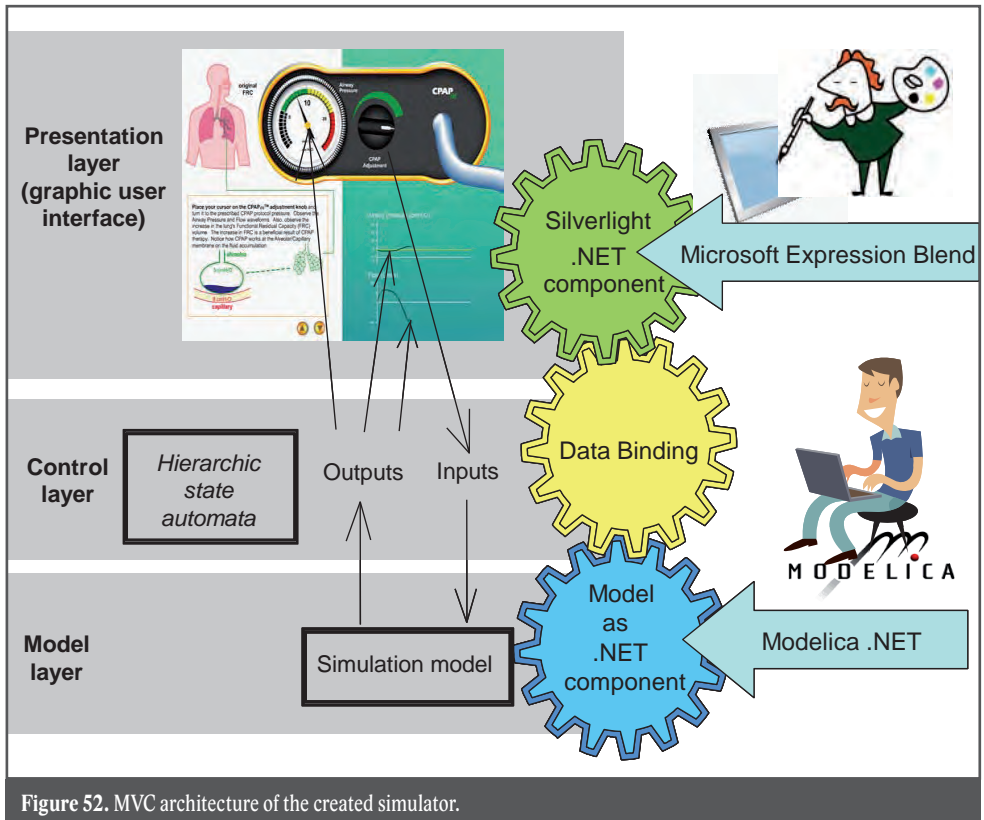


Figure 52. MVC architecture of the created simulator.

actively test their behavior and automatically generate their source code for use in the Microsoft .NET environment. This tool makes programming the links connecting the simulation model with visual objects of the user interface in the tutorial simulator possible.

Interconnection of platforms used for the creation of models, simulators and animations

When creating simulators, we are forced to work with three types of different software tools.

- Software tools for the creation and debugging of mathematical models, which will be the base of the simulator – **Matlab/Simulink** and recently with acasual tools using the **Modelica language**. It is beneficial and effective to create simulation models in this envi-

ronment, but it is problematic to operate simulators in this environment.

- A software **tool for the development of own simulator** – mostly the **Microsoft Visual Studio .NET** environment is used. In the past we were using the **ControlWeb** development environment, made by the Czech company Moravské přístroje, mainly because it offers excellent options for the quick creation of a simulator user interface – however, this interface has an overly technical character. Simple models are implemented in the ActionScript language and therefore it is sufficient to use the Adobe Flash environment, added with Adobe Flex.
- **Software tools for creation of interactive multimedia graphics** – user interface for simulators. Here, we have been using **Adobe Flash** (formerly Macromedia Flash) for a long time. Interactive animations, which may be programmed

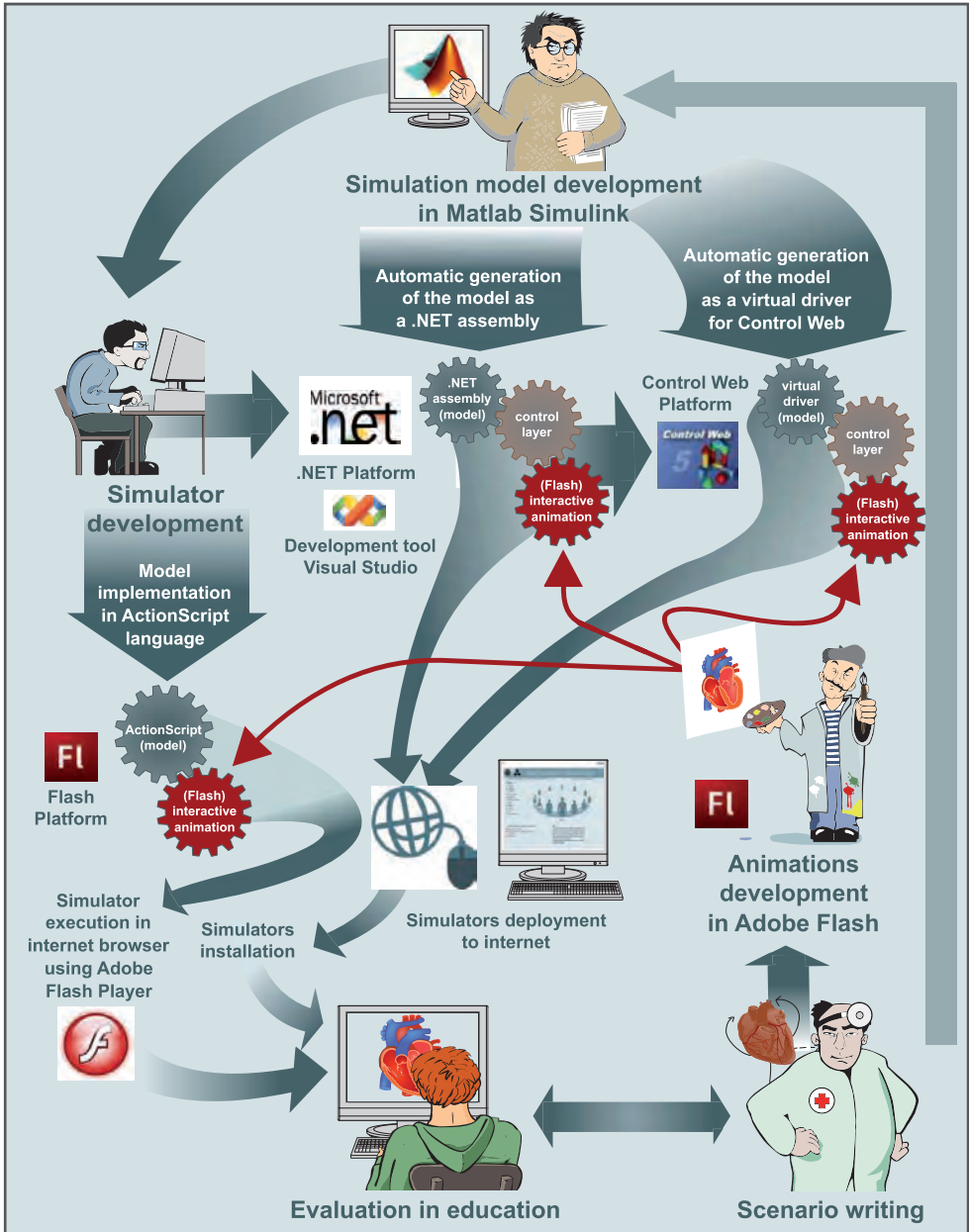


Figure 53. The original solution of creative interconnection of tools and applications, used for the creation of simulators and tutorial programmes using simulation games. The base of an e-learning program is a high-quality script, created by an experienced pedagogue. The creation of animated pictures is done by artists who create interactive animations in Adobe Flash. The core of simulators is the simulation model, created with special development tools, designed for the creation of simulation models. For a long time, we have been using Matlab/Simulink made by Mathworks for the development of models. The simulator development process is a demanding programming work. To make this task easier, we have developed special programmes that simplify the automatic transfer process of simulation models created in Matlab/Simulink over to ControlWeb or over to the Microsoft .NET environment.

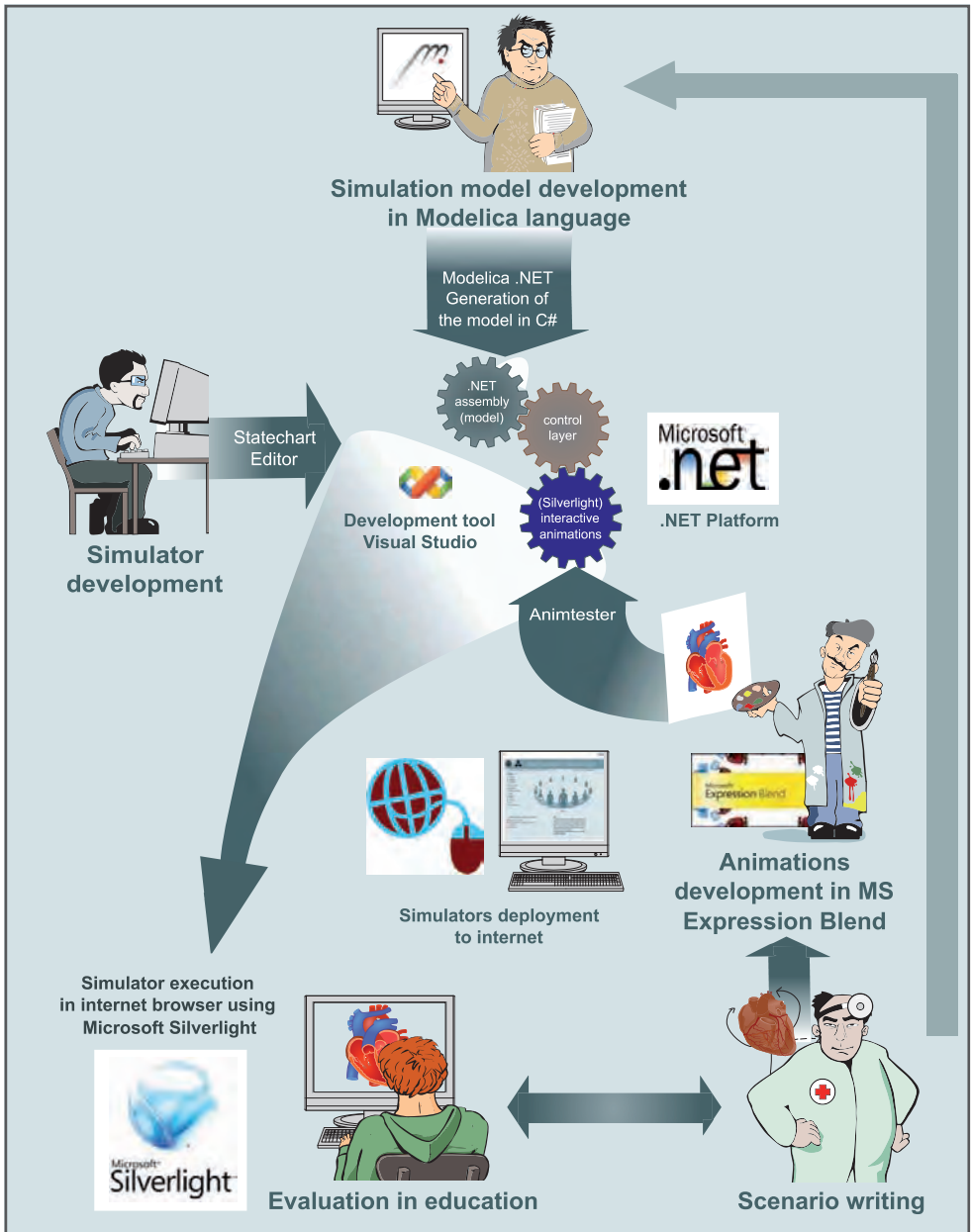
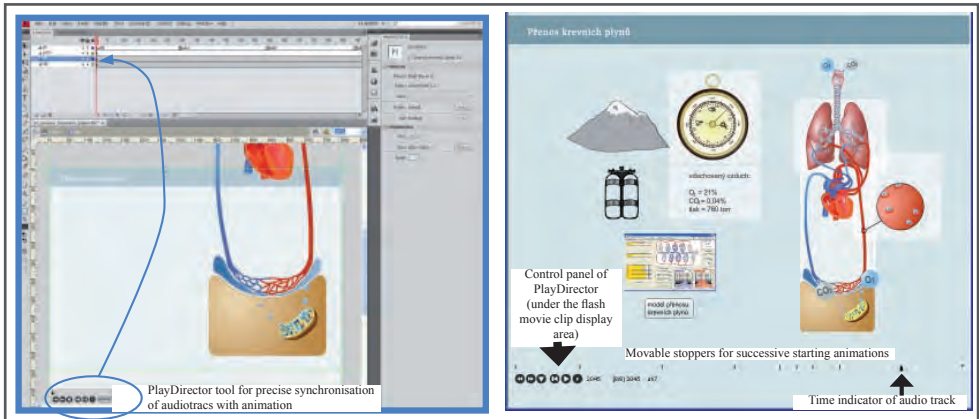
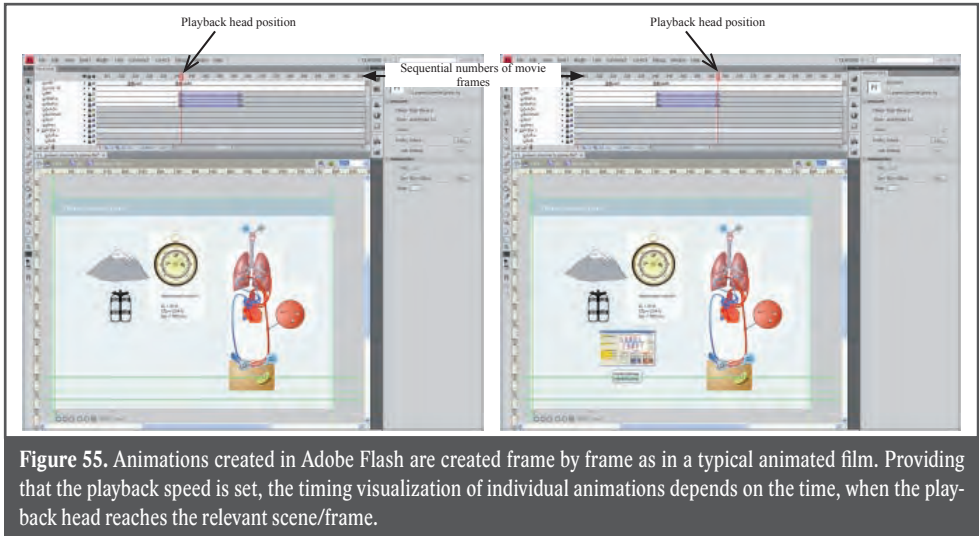


Figure 54. New solution of creative interconnection of tools and applications, used for the creation of simulators and tutorial programmes using simulation games. The base of an e-learning program is still a high-quality script, created by an experienced pedagogue. The creation of animated pictures is done by artists who create interactive animations in Expression Blend. To create and test animations that will be controlled by the simulation model, art designers use the Animtester software tool, developed by us. The core of simulators is the simulation model, created in the Modelica simulation language environment. Within the project Open Modelica Source Consortium, we are in the process of creating a tool which will be able to generate the source text from Modelica in the C# language. This will enable us to generate a component from .NET used in the final application on the Silverlight platform, which will enable us to distribute the simulator as a web application, running in the internet browser (even on computers with various operating systems).



by using the special programming language *ActionScript*, may be created here. The important thing is that animations may communicate via the software (thanks to the above-mentioned programming option in the *ActionScript* language) with their surroundings, using *ActiveX* components. Today, we prefer the *Microsoft Expression Blend* development environment before Adobe, because we can create graphic components for the *Silverlight platform*.

Because we use different development tools for simulation models and different tools for the simulator, we had to make sure that

the results are flexibly transferred from one development environment into the other one – that is for example, automated model transfer from the *Matlab/Simulink* environment over to the *Visual Studio Microsoft .NET* (in the past over to *ControlWeb*). These connection tools enabled us to develop and continuously update the mathematical model in the most suitable environment designed for mathematical model development and at the same time, to develop our own simulator in *Visual Studio .NET* (or in *ControlWeb*), without the need to “manually” reprogram the mathematical model.

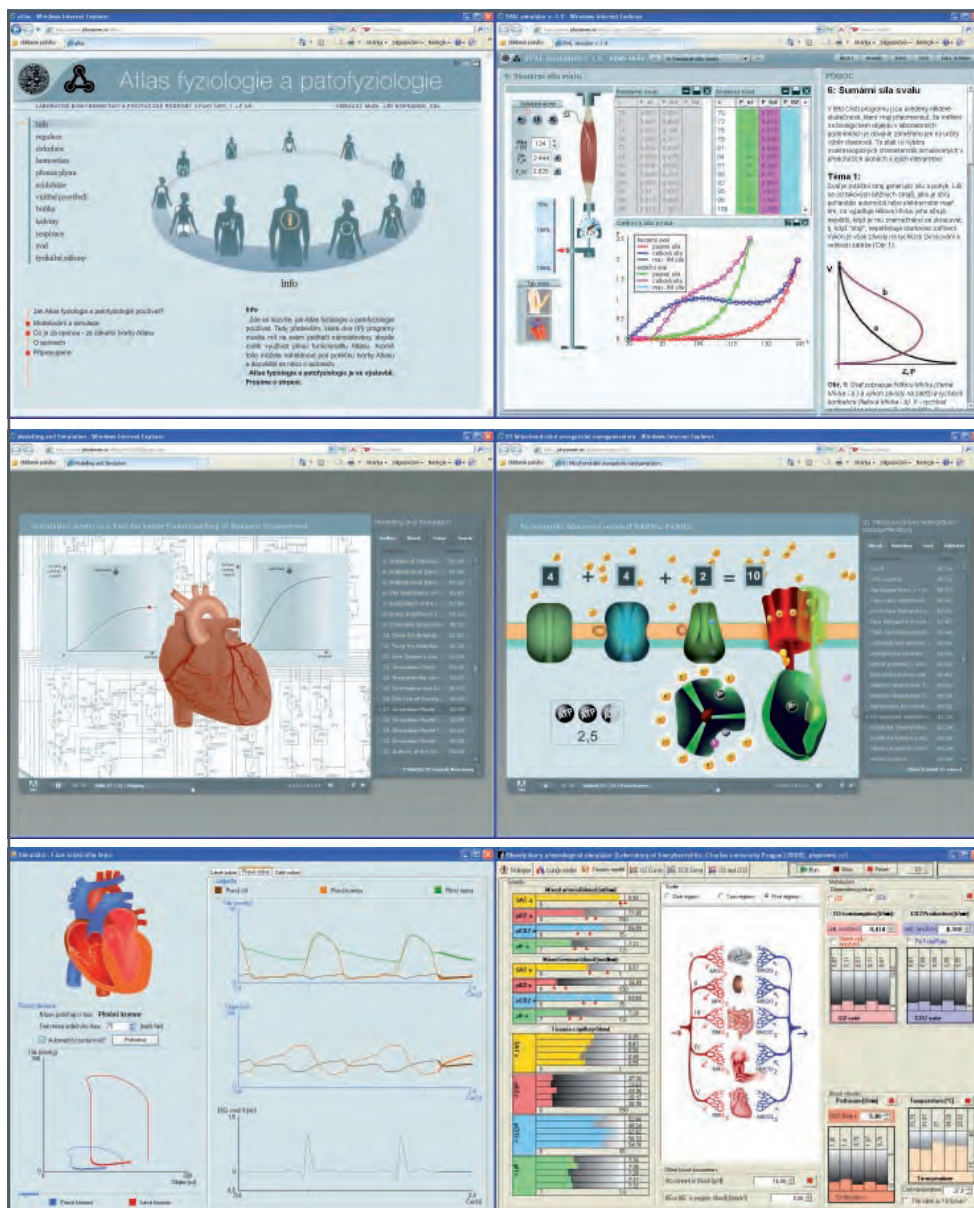


Figure 57. The Atlas of physiology and pathology combines interactive interpretations with sound, animations and simulation games. It has been created in Czech and (gradually) in an English version as well. It is freely available at: www.physiome.cz/atlas.

Also, these tools made multi-disciplinary cooperation between members of the solution team easy – system analysts creating mathematical models and programmers implementing the simulator (see Fig. 53). On the other hand, this method required working in three software environments and during each innovation we had to innovate the relevant connection tools.

From the user point of view, simulators are best distributed via the relevant web interface, which may be used also for the relevant interactive interpretation. Web based interpretation application may be easily interconnected with simple models implemented directly into ActionScript on a flash animation background (using this method we have created, for example, the tutorial

application “Mechanical properties of skeleton muscle” – <http://www.physiome.cz/atlas/sval/svalCZ/svalCZ.html>).

More complex models such as the complex model of blood gas transfer, (http://physiome.cz/atlas/sim/BloodyMary_cs/) required before the actual installation execution of the model on the client computer (and also the installation of .NET platform, which if not installed, is automatically downloaded from the Microsoft server).

The program installation process requires the user to have the relevant administration rights. Besides that, the model which runs as an independent application is connected indirectly with the web interface, where the multimedia interpretation is realized.

This problem solves our new technology of simulator creation, using the Silverlight platform (see Fig. 54). Graphical elements are created in the Microsoft Expression Blend environment.

But the simulation core needs to be realized as controlled code in the .NET environment – this should be ensured by our newly developed application Modelica .NET, which will be able to generate model code in C#.

To design the inner logic of the application we use hierarchical status instruments which are able to memorize the relevant context of the model, as well as the context of the user interface. The Statecharts editor environment, developed by us, enables the user to graphically design the instruments, to generate their code and tweak/debug them.

The benefit is that the graphical interactive elements and the simulation core are created on one platform – therefore the need to bridge between .NET and Adobe Flash, by using ActiveX components is eliminated.

The simulator must be easily combined with the interpretation chapter. The final application (the simulator and the interpretation chapter) may be realized as a web application executable directly in the web browser, without the need to install it in the client computer. It may run on various operation systems – the only requirement is to have

the Silverlight plug-in installed in the relevant web browser.

Packaging of simulation games into multimedia interpretation

A simulator without an interpretation part requires an experienced pedagogue during use. Therefore, it is beneficial to combine simulators with explanatory lectures. Interactive programmes using virtual reality models offer great tutorial and educational benefits, because they combine tutorial text with animated pictures and with simulation games and therefore, better demonstrate and present the studied problem.

Our technology includes simulation games as a part of the e-learning multimedia tutorial lesson, based on a script created by an experienced teacher. The teacher or pedagogue compiles and proposes the wording of the text, as well as the shape of the pictures and animations.

Animations are designed by artists, closely cooperating with the pedagogue working in Adobe Flash and designing them for Flash Player, operating in the internet browser or (newer technology) the Microsoft Expression Blend platform in Silverlight.

The text is then read and synchronized with each animation and with simulation game references and links. Components are then compiled into study lessons.

However, to *synchronize animation with audio* in *Adobe Flash* is not that easy.

Animations in Adobe Flash are created as in regular animated film – by each frame (see Fig. 55) and therefore, the timing sequence of the visualization depends on the time, when the “playback head” (at the preset playback speed), reaches the relevant scene/frame.

Audio track may be stored within the movie frame layer. When the synchronization process is done and animations with sound are played back, it is necessary to make sure (by using a command in ActionScript) that the played clip, playing the relevant anima-

tion, starts playing at the precise and correct time, when the playback head reaches its position.

To make the synchronization process easier, we have created a special tool called the PlayDirector – an element in the library, inserted into the created flash movie clip (Fig. 56). When the clip is played back in Flash Player, the audio tracks may be assigned interactive stoppers, according to which data are generated and used in the inserted script, which will make sure that the relevant animations will begin at the correct time.

To compile multimedia tutorial lessons created in Adobe Flash, we are using the Adobe Presenter development tool, supplied as software environment in the Adobe Connect server (Adobe Presenter may be purchased separately today – see <http://www.adobe.com/products/presenter/>).

However, the synchronization of animations with sound is much easier in the Silverlight environment. Because the animation approach in Silverlight is based on graphical property changes of the graphic objects within a certain time (unlike in Adobe Flash), the synchronization of animations with audio sounds is linear and therefore, the *Microsoft Expression Blend* environment is sufficient for this job and no other tools needs to be used or created.

Simulation games on the Web

One of the solid results of our efforts is our internet *Atlas of physiology and pathology*, created as a multimedia tutorial aid, which through the internet and through the use of the simulation model helps the teacher to explain the functions of individual physiological systems, causes and breakdowns. See <http://physiome.cz/atlas>.

Our Atlas is a part of the MEFANET network (Medical FACulties NETwork), collecting electronic study textbooks and texts of medical universities in the Czech Republic and Slovakia (<http://www.mefanet.cz/>). Currently, an integration of English texts “Teaching Resources” of the Ameri-

can physiological community into our Atlas is under way, see <http://www.apsarchive.org/>.

The Atlas combines interactive lectures and chapters and simulation games with models of physiological systems (see Fig. 57). During the creation of the model user interface, used as a base for simulation games, the atlas looked more like an atlas of animated pictures from the regular, printed Atlas of physiology (Silbernagl & Despopoulos, 2003, Czech publication 2004) or the printed Atlas of pathology (Silbernagl & Lang, 1998, Czech publication 2001), rather than abstract regulation schemes used during biomedical classes. However, contrary to the printed illustrations, pictures creating the multimedia user interface in simulators are „*alive*“ and *interactive – changes in parameters or variables will change the picture look as well*. Thanks to interactive illustrations we may create simulation games which, better than regular still pictures or simple animations, explains the dynamical relations in physiological systems and help students to understand the causes or reasons that are involved in the development of pathogeneses in various diseases.

The Atlas project is an open project – the results are freely accessible on the internet. It is created in a Czech and English version. It is an electronic tutorial aid and a part of the All educational text network. Interactive animations and simulation models, including their source codes are available to all who are interested. We would appreciate any cooperation and help from all who would like to be involved in the creation process.

Conclusion – from enthusiasm to technology and multidisciplinary cooperation

Far gone is the time when a handful of enthusiasts, excited about the new possibilities of personal computers sold during the eighties, were making their own tuto-

rial and education programmes. Computers are much more powerful today, the numeric and graphical possibilities of computers are enormous in comparison with the computers of the eighties, a huge network of high-speed internet surrounds the entire planet and represents huge potential in the modern education process.

Also development tools and the methods of the software creation process are much more powerful and advanced. At the same time, users of these software applications must be much more experienced and educated.

The creation of high-quality software capable of utilizing the huge potential offered through the information and communication technologies of today, depends on the enthusiasm and hard work of individuals. It is a demanding and complicated development process, involving all kinds of professionals and experts:

- experienced teachers, whose script is the base for high-quality tutorial application
- system analysts working with professionals and experts on the relevant field and who are responsible for the creation

of simulation models used in simulation games;

- art designers who create the outer look and visual shape;
- information specialists (programmers) who will “stitch up” the application together into its final shape.

To make sure that the work of all kinds of specialist is efficient, it is necessary to have many interconnected development tools and methods which make the cooperation between all involved members easier and helps them overcome the differences and barriers in their fields. A great deal of hard work and effort needs to be put in to master these tools, but the final results are well worth it.

The tutorial software creation process is slowly becoming a blend and a combination of pedagogical experiences and the creativity of enthusiasts. It is mostly work for specialized teams using highly specialized development tools and it is beginning to look more and more like an engineering project.

References

1. Abram, S.R., Hodnett, B.L., Summers, R.L., Coleman, T.G., Hester R.L., “Quantitative Circulatory Physiology: An Integrative Mathematical Model of Human Physiology for medical education.” *Advanced Physiology Education*, 31 (2), pp.202–210, 2007.
2. Amosov, N.M., Palec, B.L., Agapov, G.T., Ermakova, I.I., Ljabach, E.G., Packina, S.A., Soloviev, V.P. *Theoretical research of physiological systems (in Russian)*. Naukova Dumaka, Kiev, 1977.
3. Bassingthwaite J. B., “Strategies for the Physiome Project”, *Annals of Biomedical Engineering* 28, pp. 1043–1058, 2000.
4. Brudgård, J., Hedberg, D., Cascante, M., Gedersund, G., Gómez-Garrido, A., Maier, D., Nyman, E., Selivanov, V., Stralfors, P., “Creating a Bridge between Modelica and the Systems Biology Community”, *Proceedings 7th Modelica Conference*, Como, Italy, Sep. 20–22, 2009., pp. 473–479, The Modelica Association., Como, 2009. Available: <http://www.ep.liu.se/ecp/043/052/ecp09430016.pdf>.
5. Cellier, F. E., Nebot, A., “Object-oriented modeling in the service of medicine”, *Proceedings of the 6th Asia Conference*, Beijing, China 2006. 1, pp 33–40. International Academic Publishers, Beijing, 2006
6. Coleman T.G, Hester, R., Summers, R. (2008, July): Quantitative Human Physiology [Online] Available <http://physiology.umc.edu/themodelingworkshop/>

7. Collins, D. (1995). *Designing object-oriented user interfaces*. Benjamin Cummings (ISBN: 0-8053-5350-X), Redwood City, CA, 1995.
8. Dabney J.B., Harman T.L., *Mastering Simulink*, Prentice Hall (ISBN: 0-13-142477-7), Houston, 2004,
9. Grodins F.S., Buell J., Bart A.J., "Mathematical analysis and digital simulation of the respiratory control system.", *J.Appl. Physiol.*, 22 (2), pp. 260–276, 1967.
10. Guyton AC, Coleman TA, and Grander HJ., "Circulation: Overall Regulation.", *Ann. Rev. Physiol.*, 41, 13–41, 1972.
11. Guyton A.C, Jones C.E and Coleman T.A., *Circulatory Physiology: Cardiac Output and Its Regulation*. WB Saunders Company, Philadelphia, 1973.
12. Fencl, J., Jabor, A., Kazda, A., Figge, J., "Diagnosis of metabolic acid-base disturbances in critically ill patients", *Am. J. Respir. Crit. Care.*, 162, pp. 2246–2251, 2000.
13. Fritzson P, *Principles of Object-Oriented Modeling and Simulation with Modelica 2.1*, Wiley-IEEE Press (ISBN 978-0-471-47163-4), Piscataway, NJ., 2003
14. Haas, O. C., Burnham, K. J., "Systems Modeling and Control Applied to Medicine", in O. C. Haas, & K. J. Burnham, *Intelligent and Adaptive Systems in Medicine*, pp. 17–52, CRC Press, Boca Raton FL, 2008.
15. Hall J.E., "The pioneering use of system analysis to study cardiac output regulation", *Am.J.Physiol.Regul.Integr. Comp.Physiol.* 287, pp. 1009–1001, 2004.
16. Harel, D., "Statecharts: a visual formalism for complex systems", *Science of Computer Programming* 8, pp. 231–274, 1987.
17. Hester L. R., Coleman T., Summers, R., "A multilevel open source model of human physiology." *The FASEB Journal*, 22, p. 756, 2008
18. Hunter P.J., Robins, P., Noble D., "The IUPS Physiome Project", *Pflugers Archive-European Journal of Physiology*, 445, pp. 1–9, 2002.
19. Ikeda N, Marumo F and Shirsataka M. A., "Model of overall regulation of body fluids", *Ann. Biomed. Eng.* 7, pp. 135–166, 1979.
20. Khoo M.C., *Physiological Control Systems: Analysis, Simulation, and Estimation*, .IEE Press (ISBN 0-7808-3408-6), New York 2000,
21. Kofránek, J., "Modelling of blood acid base balance", Ph.D, Thesis, Charles University, Faculty of General Medicine, Prague, 1980.
22. Kofránek, J., & Svačina, Š., "Multimedia simulators of glycoregulatory mechanisms as an interactive teaching tool,," in J. G. Anderson, & M. Kapzer (Editor), *Simulation in the Health and Medical Sciences 2001*, pp. 165–170. Society for Computer Simulation International, Simulation Councils, San Diego, 2001.
23. Kofránek J. Anh Vu L. D., Snášelová H., Kerekeš R. and Velan T., "GOLEM – Multimedia simulator for medical education", in *MEDINFO 2001, Proceedings of the 10th World Congress on Medical Informatics*. (London, UK, 2001), Patel, L., Rogers, R., Haux R. Eds., pp. 1042–1046, IOS Press, London, Available <http://www.physiome.cz/references/MEDINFO2001.pdf>.
24. Kofránek, J., Andrlik, M., Kripner, T., & Mašek, J., "Simulation chips for GOLEM – multimedia simulator of physiological functions", in J. G. Anderson, & M. Kapzer (Editor), *Simulation in the Health and Medical Sciences 2002*. pp. 159–163, Society for Computer Simulation International, Simulation Councils, San Diego, 2002. Available <http://www.physiome.cz/references/SimChips2002.pdf>.
25. Kofránek, J., Andrlik, M., Kripner, T., & Stodulka, P., "From Art to Industry: Development of Biomedical Simulators", *The IPSI BgD Transactions on Advanced Research* , 1 #2(Special Issue on the Research with Elements of Multidisciplinary, Interdisciplinary,

- and Transdisciplinary: The Best Paper Selection for 2005), pp. 62–67. 2005. Available at <http://www.physiome.cz/references/IPSI2005.pdf>.
26. Kofránek, J. (Director), Klučina, P. (Script), Kofránek, J. (Producer), Rejl, V. (Designer), and Obdržálek, J. (Music), *Möten i historien, Historica encounter, Dějinné setkání*, Motion picture film. Bajt servis s.r.o. in cooperation with Charles University. Prague, 2006.
 27. Kofránek, J., Ruzs, J., Matoušek S., “Guytons Diagram Brought to Life – from Graphic Chart to Simulation Model for Teaching Physiology”, in Technical Computing Prague 2007. Full paper CD-ROM proceedings. (P. Byron Ed.), pp. 1–13, Humusoft s.r.o. and Institute of Chemical Technology, Prague, 2007. Available (including source code): <http://www.humusoft.cz/akce/matlab07/sbor07.htm#k>
 28. Kofránek, J., Matoušek, S., & Andrlík, M., “Border flux ballance approach towards modelling acid-base chemistry and blood gases transport”, in V B. Zupanec, S. arba, and S. Blažič (Editor), Proceedings of the 6th EUROSIM Congress on Modeling and Simulation, Full Papers (CD) (TU-1-P7-4, pp. 1–9), University of Ljubljana, Ljubljana 2007. Available: <http://www.physiome.cz/references/ljubljana2007.pdf>.
 29. Kofránek, J., Mateják, M., Matoušek, S., Privitzer, P., Tribula, M., & Vacek, O., “School as a (multimedia simulation) play: use of multimedia applications in teaching of pathological physiology.” MEFANET 2008. CD ROM Proceedings, (ISBN 978-80-7392-065-4), kofranek.pdf: pp. 1–26, Masarykova Univerzita, Brno, 2008. Available: <http://www.physiome.cz/references/MEFANET2008.pdf>.
 30. Kofránek, J., Mateják, M. Privitzer, P., Tibula, M., “Causal or acausal modeling: labour for humans or labour for machines”, in V C. Moler, A. Procházka, R. Bartko, M. Folin, J. Houška, P. Byron (Editor), Technical Computing Prague 2008, 16th Annual Conference Proceedings, CD ROM, 058_kofranek.pdf: pp. 1–16. Humusoft s.r.o., Praha, 2008, Available: <http://www.physiome.cz/references/TCP2008.pdf>.
 31. Kofránek, J., “What is behind the curtain of a multimedia aducational games?” in EATIS 09 Contribution Proceedings. Euro American Conference on Telematics and Information Systems, 2009. (ISBN 978-80-87205-07-5, 229–236), Wirellesscom sro., Prague, 2009. Available: <http://www.physiome.cz/references/eatis2009.pdf>.
 32. Kofránek, J., “Complex model of acid-base balance (in Czech).”, in M. Zeithamlová (Editor), MEDSOFT 2009, Praha: Agentura Action M., pp. 23–60. English translation of the paper is available at <http://www.physiome.cz/references/medsoft2009acidbase.pdf>, model is available at <http://www.physiome.cz/acidbase>.
 33. Leff, A., Rayfield, J. T., “Web-application development using the Model/View/Controller design patterns”, in Fifth IEEE International Enterprise Distributed Object Computing Conference, (ISBN: 0-7695-1345-X), IEE International, Seattle, 118, 2007
 34. Little, J. A., Beres, J., Hinkson, G., Rader, D., Croney, J., Silverlight 3 programer’s reference (Wronx programer to programer). Wronx Wiley, Indianapolis, 2009.
 35. Logan, J. D., Wolesensky, J. D., Mathematical methods in biology. Wiley, Hoboken, NJ, 2009.
 36. McLeod, J., “PHYSBE: A ophysiological simulation benchmark experiment”, Simulation, 15: pp. 324–329, 1966.
 37. McLeod, J., “PHYSBE...a year later”, Simulation, 10, pp. 37–45, 1967.
 38. McLeod, J., “Toward uniform documentation-PHYSBE and CSMP”, Simulation, 14, pp. 215–220, 1970.
 39. Obdržálek, J., Kofránek, J., Tuning theory, mutimedia educational program (in Czech), Charles University Prague, 1st Medical Faculty, Prague, 2004. available: z <http://patf-biokyb.lf1.cuni.cz/~obdrzalek/ladeni.htm>.

40. Oomnes, C., Breklemans, M., Baaijens, F., Biomechanics: concepts and computation. Cambridge University Press, Cambridge, 2009.
41. Raymond, G. M., Butterworth E, Bassingthwaight J. B., “JSIM: Free Software Package for Teaching Physiological Modeling and Research”, *Experimental Biology*, 280, pp. 102–107, 2003.
42. Sirker, A. A., Rhodes, A., Grounds, R. M., “Acid-base physiology: the ‘traditional’ and ‘modern’ approaches”, *Anesthesia*, 57, pp. 348–356, 2001.
43. Stewart, P. A., “Modern quantitative acid-base chemistry”, *Can. J. Physiol. Pharmacol.*, 61, 1444–1461, 1983.
44. Stodulka, P., Privitzer, P., Kofránek, J., Vacek, O., “Development of WEB accessible medical educational simulators”, in V B. Zupanec, R. Karba, & S. Blažič (Editor), *Proceedings of the 6th EUROSIM Congress on Modeling and Simulation*, Vol. 2. Full Papers (CD). (MO-3-P4-2: pp. 1–6). University of Ljubljana, Ljubljana, 2007. Available: <http://www.physiome.cz/references/EUROSIM2007Stod.pdf>.
45. Wallish, P., Lusignan, M., Benayoun, M., Baker, T. I., Dickey, A. S., Hatsopoulos, N. G., *MATLAB for Neuroscientists: An Introduction to Scientific Computing in MATLAB*. Academic Press, Burlington, MA, 2008.
46. Thomas, R. S., Baconnier, P., Fontecave, J., Francoise, J., Guillaud, F., Hannaert, P., Hermandéz, A., Le Rolle, V., Mazière, P, Tahi, F, White R. J., “SAPHIR: a physiome core model of body fluid homeostasis and blood pressure regulation”, *Philosophical Transactions of the Royal Society*, 366, pp. 3175–3197, 2008.
47. Van Vliet, B.N., Montani J.P., “Circulation and fluid volume control”, in: *Integrative Physiology in the Proteomica and Post Genomics Age*, (ISBN 918-1-58829-315-2, 43–66), Humana Press, 2005, .

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INNOVATION OF MICROSCOPE MORPHOLOGY EDUCATION IN HEMATOLOGY USING INTERNET VIRTUAL INTERACTIVE METHOD

Faber E., Szotkowski T., Kajaba V., Juráňová J., Flodr P., Procházka V., Papajík T., Hluší A., Vondráková J. and Důjková V.

Palacký University in Olomouc

Abstract

Classic forms of teaching of microscope morphology have reached their limits. Further development is possible by using of e-learning. To improve teaching of morphology in hematology of students at Palacký University we decided to use the technology of virtual microscopy. Our project was supported by ESF and state budget of Czech Republic through the Operating program Education for Competitiveness provided by the Czech Ministry of Education Youth and Sports. The main aim of the project is to improve efficacy of microscope morphology in hematology education using digital virtual technology and improve the knowledge of hematologic morphology in target groups and to verify this improvement. Electronic manual containing instructions how to use the microscopy optimally and how to use the e-learning tools will be provided at special internet site. Issuing of a special textbook on elementary diagnostics containing descriptions of individual diseases with typical results of blood counts and morphology will be prepared. After login student will pass an entry test in order to evaluate the knowledge before e-learning. After that education sets of typical morphology findings will be available at web site. The knowledge achieved by e-learning will be assessed by check out test. The level of the e-learning course will be adapted to the actual study course. The participants will be able to improve their knowledge not only in hematology but also in modern education methods. A new modern digital database of hematologic morphology and a special web site both in Czech and English will be prepared. All materials will be validated by the panel of Czech and foreign experts. The database and technologies will serve for further educational needs. Electronic and printed textbook and manual book will be the additional results of the project. This project has been registered under number CZ.1.07/2.2.00/07.0294.

Keywords

microscopic morphology in hematology, virtual microscopy, e-learning

Introduction

Microscope morphology in hematology is currently a wrongly neglected and cheap method capable of making a safe diagnosis in many cases when combined with other common tests. Many physicians as well as laboratory technicians are observed to lose their experience and skills if they lack motivation and work in smaller facilities where it is difficult to encounter certain morphological findings frequently enough. Moreo-

ver, traditional methods are often underestimated when compared with newer, more sophisticated and expensive methods such as immunophenotyping or molecular genetics. In numerous cases, however, a simple morphological assessment, sometimes combined with another commonly available and cheap test, is sufficient for making a safe diagnosis. Subsequently, the patient is referred to a specialized center for further treatment. For economic reasons, many

hospitals tend to fuse their biochemistry and hematology laboratories. These laboratories are usually not staffed by hematologists and the laboratory technicians, inadequately trained in hematology, are unable to assess many findings (including morphological) properly and inform the physicians. Current medical education is still being criticized for putting more emphasis on theoretical knowledge than on practical training. Our project has been prepared to improve practical skills and abilities to correctly interpret the results of basic laboratory investigations. The project will extend the possibilities of training in hematology and internal medicine and significantly improve the access to microscopic findings in peripheral blood and bone marrow. Unlike traditional printed or electronic atlases (providing images of a small portion of the field of view of a microscope, or a group of cells), this approach will be practically identical to microscopy of an entire cytology preparation.

Goals of the project

The goals are to improve the knowledge of hematology morphology in the target groups and to verify the improvement. Following regular practical training in hematology or internal medicine included in the general medicine curriculum, Palacký University Olomouc medical students will be granted an access to a web education portal. There, a manual in an electronic format will be available, describing the basics of microscopy and assessment of microscopy findings, and a user's guide to the web portal. This information, together with a brief overview of basic hematologic diagnoses and changes in blood count, will be summarized in a student textbook compiled as a part of the project. After logging in to the portal, students will first have to assess an initial set of morphological findings to evaluate their previous knowledge acquired by common methods. Following the entrance test, the participants will have an access to a study set, with an opportu-

nity to significantly extend their knowledge of morphology in hematology. After a pre-defined period of time, the students will be able to verify their knowledge in an exit test. The test results will be compared to provide information about the improved ability to adequately assess morphological findings in both hematologic and non-hematologic conditions. The difficulty levels of the course will be adjusted to the specific study programs (either internal medicine or morphology in hematology for medical students and laboratory technicians). The project will contribute to better acquisition of theoretical and practical knowledge from other phases of training. It will also generally improve the quality of students' knowledge and competitiveness in hematology. The course participants will not only learn more about hematology but they will also become proficient in the use of modern study methods. For the project, a modern digital database of morphological findings will be created, together with a web portal with Czech and English texts reviewed by both domestic and foreign experts. Given the technology used, the database will serve for continuing education as well. The other project outcomes will be a student textbook and printed and electronic-format manuals.

Expected contribution of the project

Students in the target group are expected to become more proficient in the use of microscopy in hematology, to evaluate basic morphological findings in blood and bone marrow smears and to establish a correct diagnosis in many cases. The web-based self-study, technically very similar to real microscopy, will provide the students with much more time needed to practise assessment of the findings. This should result in both qualitative and quantitative effects, as compared with traditional study of images in hematology atlases or standard websites (usually individual images of a single cell or just a few cells), and much higher levels of

practical knowledge that is crucial for physicians' and laboratory technicians' practice. A better comprehension of morphology will help students to acquire a more detailed understanding of individual diseases, their

pathogenesis and relations between them. When compared with traditional forms of teaching, students should be better prepared for their future practice.

06

AKUTNE.CZ PROJECTS – HOW TO JOIN MEDICAL STUDENTS TO E-LEARNING CONTENT DEVELOPING

Štourač P.¹, Kříkava I.¹, Schwarz D.², Štouděk R.¹, Bakalík P.¹, Smékalová O.¹, Breyer L.¹, Ševčík P.¹, Šnábl I.², Šustr R.², Ďurišová Z.³, Wollfová J.³, Maková L.³, Izakovič M.³, Hons M.³, Mayer J.³, Kolářová G.³, Krátka E.³, Kosinová M.³, Chovanec M.³, Chvátal Z.³, Malý M.³, Krajtlová E.³, Kuchař D.³

¹ *Department of Anaesthesiology, Resuscitation and Intensive Care Medicine, Medical Faculty, Masaryk University, Faculty Hospital Brno, Brno, Czech Republic*

² *Institute of Biostatistics and Analyses, Masaryk University, Brno, Czech Republic*

³ *Medical Faculty, Masaryk University, Brno, Czech Republic*

Abstract

Introduction: AKUTNE.CZ – large-web-based tutorial portal is from the beginning focused on acute medicine e-learning. Medical students participation was found as a key factor. We will present some AKUTNE.CZ projects.

Methods: We are using hierarchic form of administration. On the top of the chain are chapter guarantees. Recruitment of students proceeds continuously by topics publication. Other way of propagation is using of AKUTNE.CZ portal during lessons.

Results: The most successful project is “Multimedia tutorial algorithms”. More than 15 students participate in this project. A very important part of it is the presentation at national or international congresses. Students make very often online reports from the congresses. The newest project is “Multimedia broadcast from operating theatres”, that brings atmosphere of the operating theatre to lessons and homes of students. It simultaneously allows storage, processing and broadcasting of real medical situations.

Conclusion: AKUTNE.CZ projects won the main prize for anesthesiology in 2009.

Keywords

acute medicine, publication portal, decision algorithms, medical students

Introduction

AKUTNE.CZ – large web-based tutorial portal [ISSN 1803-197X] has been from its beginning in 2007 focused on acute medicine e-learning. It elucidates in an attractive way acute medicine, the field which occurs in all medicine but is often forgotten. AKUTNE.CZ portal makes accessible in a multimedia way themes concerning not only propaedeutics of acute medicine. The unique goal of AKUTNE.CZ portal is to make a file of audiovisual interactive decision algorithms which enables in practice to verify thinking ability in a case of an urgent patient. Making next algorithms from the

field of acute medicine still remains the main priority of the creative team. The next project is “Multimedia broadcast from the operating theatre”, which deals with important limiting factors occurring every day during tuition in operating theaters, such as capacity utilization, spatial arrangement of the operating theatres, hygiene standards, visibility of the operating field and number of students. Universal videoconferencing approach offers a wide spectrum of anesthesiological and surgical performances during tuition, on AKUTNE.CZ portal, at conferences and other e-learning activities.

Methods

During AKUTNE.CZ portal development we use so-called open-source software and free accessible technologies. This allowed to make the portal platform independent and to reduce costs. During development of the portal we use script language PHP and database MySQL. The sites are coded in XHTML. The portal includes statistical data, especially in the form of lectures or authorized articles on certain subjects. The professional level of e-learning algorithms is reviewed by outstanding personalities of relevant fields, especially by members of AKUTNE.CZ editorial and review board. One of our next goals was platform independent data accessibility. Communication interface between the authors of medical data and programmers were XHTML forms. They became a part of administrative portal interface and contain the accurate description of algorithm nodes. From them are directly formed complete block diagrams in XML with direct convert into flash animation. So the algorithm is prepared for presentation. Flash animation was used because of the high percentage of users (in 2008 94% of users of this portal). Graphic algorithm layout is updated in version 2.0 and enriched with information important for decision of the acute patient. After signing the approval by the patient are the multimedia data took with a camcorder or camera in the real or simulated situations keeping strict anonymity of the patient. For the higher authenticity of urgent situations are as algorithm stress factors chosen

time, several block diagram possibilities and the possibility of direct fatal algorithm finish in the case of a serious medical mistake. The realization team consists of more than 15 students of The Faculty of Medicine, 8 doctors, 2 programmers, 1 graphic designer and 3 reviewers. For maximum using of financial resources and mediating the broadcast to an unlimited number of recipients in any locality is videoconferencing based on streamline server Tangberg Content which offers maximum connectivity of simultaneous signal supplies (HD camera, output of the bronchoscope, video laryngoscopes, microscopes, scopic towers, etc). The server allows transmission of two simultaneous broadcasts (one operation is possible to watch simultaneously from the view of both the anesthesiologist and the operator within two lessons in two rooms), five simultaneous records and unlimited number of recorded broadcasts in unicast or multicast mode. Picture and sound are scanned through the videoconferencing equipment which is situated directly in the operating theatre. This equipment is connected to the local area network with guaranteed speed 2Mbps. The stream is recorded on the server and transmitted immediately or subsequently. The client station can be any equipment (PC, mobile phone, PDA, palmtop, etc.) with connection to the Internet or designated network which is able to decode audiovisual signal standard H.264.

Results

Graphic design of the web portal follows modern web design trends, rules of accessibility and use of websites. The core of the portal and particular interactive parts – tests, decision algorithms for students, lecturers and administrators is also programmed in accord with current trends. There are online updated handouts in several courses on the portal. The presentation of AKUTNE.CZ at the XV and XVI National Congress ČSARIM and during Postgraduate Course on Sepsis and MODS helped to

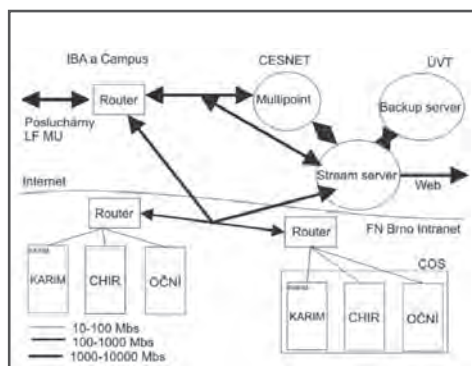


Figure 1. Videoconference Broadcast Scheme.



Figure 2. Algorithm Layout 2.0.

improve the co-operation with students. Our activities are supported by professional associations working in acute medicine (ČSARIM, ČSIM, ČSFPS). Number of AKUTNE.CZ visitors in 2009 overstepped 4,000 unique IP addresses which shows a high interest. Videoconference e-learning of anesthesiology has expanded the portal. It helps technically and administratively cover the practical tuition of anesthesiology and offers live and recorded streams to AKUTNE.CZ. The final result brings shots from the central operating theatres, anesthesiological preparing rooms and postoperative rooms to The University Hospital Brno, The Faculty of Medicine MU Brno or anywhere in the world (Figure 1). Multimedia interactive algorithms brought updated 2.0 layout version with several modalities including the possibility of video playing directly in the algorithm and the possibility of team work directly in the BackOffice of the portal (Figure 2). The result are algorithms on the following topics – “Acute Asthma”, “Difficult Airway Management”, “Cardiopulmonary Resuscitation”, “How to Go Through Sepsis?”, “Approach to Neurotraumatic Treatment”,

“Acute Pain Management” and “Invasive Securement of a Critically Ill Patient”.

Conclusion

The quality of the relevant parts of AKUTNE.CZ is guaranteed by the chapter guarantees, editorial and review board. Videoconferencing solution with the possibility of the Internet stream enabled the portal AKUTNE.CZ to transmit live or recorded broadcasts, for example, at the MEFANET conference. The quality of interactive algorithms is based on the multistage reviewing of independent professionals for acute medicine in the relevant fields and guarantees of the portal chapters. The portal is accessible on <http://www.akutne.cz>. The evidence of the portal attractiveness for students show not only several thousands unique IP addresses per month but also more than 15 students who are taking part in the portal development. AKUTNE.CZ projects won the main prize for anesthesiology in 2009.

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UTILIZATION OF 3D PROJECTION IN EDUCATION OF CLINICAL DISCIPLINES

Majerník J., Majerníková Ž., Pomfy M.

Faculty of Medicine, Pavol Jozef Šafárik University in Košice, Košice, Slovakia

07

Abstract

Modern tools intended to support educational process offers possibilities that allow teachers to present their themes in an effective and more demonstrative way. Teaching of not only technical but also humanitarian disciplines is then attacked by two different approaches. Both have already transferred the load of education on information and communication technologies, but it is not clear if there the attendance or distance forms should be preferred. Whatever opinion is used, the main goal and the result of education process should be to offer an actual knowledge from particular discipline. On the other hand, the students have to be allowed to learn and utilize new things in as understandable way as possible. Here, the simulations and virtualization methods can be used to revive education. The detailed study of human body, its apparatus and also description of different surgery processes at the Faculty of Medicine in Košice will be supported by the system of 3D virtual projection.

Keywords

education, virtual projection, simulation, 3D projection

Introduction

Utilization of modern technologies brings into the pedagogical process new dimensions, increases its quality, supports a specialized and professional advancement for both students and teachers, and last but not least increases scientific horizon of graduates and their application on the labor market. Nowadays, creation of electronic education materials is in most cases oriented on renewing of static presentations and their explanation using computer graphics tools. Also, the question of communication between the teacher and his/her students paves the way to the more efficient modes. Many systems developed with the aim to support and control education process, as are for example the educational portals, LMS, WLE etc, have such methodology at very high sophisticated level. Effectiveness of their practical usage depends in great measure mostly on organization of educational process. However, resonant questions that still remain unanswered are personal contact of teacher with students and appre-

hension from possible “deceptions” while a distance study form and also evaluation process are realized only in on-line form. One of the alternatives reviving education and bringing into the system the new technologies, maintaining the necessary presence form of education is utilization of tools that simulate activities of real life.

Virtualization

Institutions of which main mission is to provide education, increasingly tries to improve attractiveness, flexibility and in final consequence also the quality of their study programs by advanced forms of education, that are usually based on most modern information and communication technologies. Fruitfulness of their realization and utilization reflects the symbiosis of quality sustainment for everybody involved in education processes.

To solve the above mentioned tasks the virtual laboratories, classrooms and even whole schools and universities are established. Such forms are in many scientific



Figure 1. Audience of lecture room with installed 3D virtual projection system.

and professional areas very successful and often more effective than their “stone” competitions. The university students can complete education from anywhere and at any time. Likewise, the teachers can utilize their working time more effectively; they can prepare qualitative better content of e-learning courses and/or to organize videoconferencing lectures. In the case of videoconference lectures, the students still have the advantage to participate on particular lecture, even virtually and in real time. Independence on physical buildings of educational institution also allows involving of professionals from all over the world into the educational process. Access to the lectures and/or to on-line conference can be limited by convenient form of authentication. This ensures that the teachers will offer education only for students that are verified as students of their groups or faculties.

Even if the modern technologies bring many advantages, it is impossible and often unimaginable to realize some of study programs only in distance form. Here, it can be included also the study of clinical disciplines. To increase attractiveness of particular subject the opposite approach must

be used. It means to utilize technologies directly in presence study form.

3D projection

Teaching of specialized pre-clinical subjects requires demonstrative aids and tools that allow students to see and understand background of particular organs, muscles, bones, functional systems etc. Such equipment should offer a better way to classify their structure and functions, to reveal deeper details and other related connections. Everything must be classified in better form than is a book or standard printed 2D graphics. Other disadvantage of convenient approach is that some details are almost unimaginable and for beginning medical students incomprehensible. Absence of post-mortem materials, impossibility to realize routine as well as more exacting surgery procedures or inaccessibility of patients for education purposes opens the space for simulation systems that eliminate here mentioned disadvantages. To improve the education at the Pavol Jozef Safarik University in Kosice Faculty of Medicine the 3D virtual projection system was established. We expect the system will increase the inter-

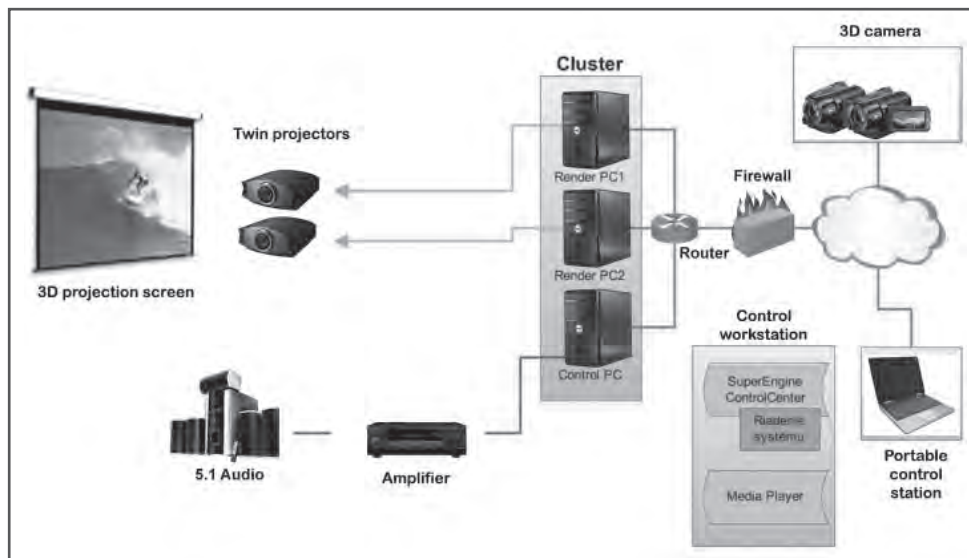


Figure 2. Principle scheme of large screen projection installed in lecture room for 200 students.

est of students in presence forms of study and the quality of lecture content as well.

3D projection systems are based on principles of virtual reality and are presented as rooms that are equipped by one or more projection screens. Using specialized glasses the students – consumers of educational content feel an existence of 3D space. 3D virtual projection system is installed in lecture room with the capacity of 200 students. It consists of three main components. These include

- large screen projection;
- teacher workstation;
- 3D camera system.

The projection equipment is based on PC cluster, twin projectors, special silver screen, 3D glasses and 5.1 audio system. PC cluster consists of 3 high performance PCs. Two PC creates graphical output for projectors respectively. One picture is prepared for left eye and another one for the right eye. The third PC controls all the activities that are necessary 3D projection.

The role of large screen projection is to show 3D models, 3D realistic movies and pictures, but also 3D animated movies or its combination with real records. To control the system the portable computer workstation with specialized software is used

directly in the lecture room as the high performance cluster is located in separate room.

Teacher workstation consists of specialized computer with high-performance graphic card and specialized 3D monitor. It is used by the authors of 3D educational materials (movies, models etc.) to prepare its content before the lecture. Except of movies it allows to add descriptions, sounds and other recorded audio comments.

3D camera is constructed as a connection of two HD cameras mounted and fixed in metallic frame. This stationary set positioned on robust stand consists also from controller for synchronous controlling of cameras, control station and appropriate accessories. It is used to record real 3D movies but also in combination with workstation of projection to realize live 3D broadcasts directly to lecture room.



Figure 3. Main components of teacher workstation.

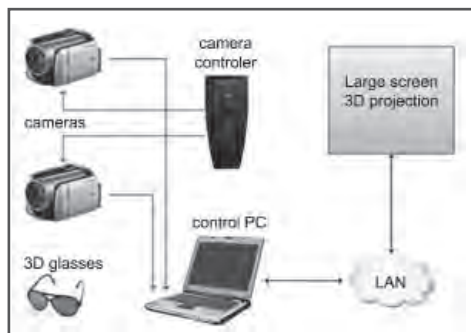


Figure 4. Principle scheme of 3D camera system. The cameras can be operated with control system that allows direct control of education material or to realize live broadcast. Cameras without the control system are more portable.

3D virtual projection system was designed to offer complex functions of 3D presentation primarily for medical purposes to support education of clinical and health care disciplines. Furthermore, it is designed as modular what offers possibilities to adopt it to the needs of lecturers and to increase its functions when needed. Actual configuration provides:

- projection of 3D movies – presentation of real 3D movies recorded by 3D camera (including surgery procedures, medical treatment procedures, rehabilitation techniques etc.)
- projection of 3D animated movies – presentation of 3D movies prepared as computer animations (usually teaching materials prepared from 3D model of human body)

- projection of 2D movies – used when some of the scenes were recorded only with one single non 3D camera
- projection of 3D content in real time – presentation of 3D model in case when no material was prepared before the lecture (teacher works with the system and 3D content directly during lecture)
- live 3D projection – presentation of real scenes directly from 3D camera (3D videoconference).

Conclusion

The successful implementation of virtual tools and virtual support forms into the presence forms of education brings many advantages. Except of others the direct students' response is transferred to the teachers, and he or she can reflect it preparing more precise and more qualitative educational works. All the virtual reality outputs can be easily converted to the forms that are applicable into the systems intended for distance education.

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References

1. Majerník, J., Pomfry, M., Majerníková, Ž.: Virtuálne formy podpory vzdelávania v medicínskych odboroch. MEFANET 2009, 3. konferencie lekárskejších fakúlt ČR a SR s mezinárodnou účasťou na téma e-learning a zdravotnícká informatika ve výuce lekárskejších odborů, 25.–27. 11. 2009, MSD Brno, ISBN 978-80-7392-118-7.
2. Majerník, J., Ďuratný, M.: 3D systém virtuálnej projekcie a vzdelávanie študentov medicíny. Seminár “Využitie nových technológií vo vzdelávaní na lekárskejších fakultách”, 15. 2. 2010, UPJŠ LF Košice.
3. Slovakia Supercomputers s.r.o., [Online, 9. 1. 2010]. Available: <http://www.supercomputers.sk>

B

**EDUCATIONAL
PORTALS, LEARNING
MANAGEMENT
SYSTEMS AND
E-TESTING AGENDA
IN MEDICAL
EDUCATION**



mefanet

NEW COMPONENTS AND FUNCTIONALITY OF THE COMMON PORTAL PLATFORM IN THE MEFANET PROJECT

Schwarz D.¹, Šnábl I.¹, Dušek L.¹, Feberová J.²

¹ *Masaryk University, Institute of Biostatistics and Analyses*

² *Charles University in Prague, 2nd Faculty of Medicine*

Abstract

MEFANET has decided to develop an original and uniform solution for educational web portals which are used, together with a central gate, to offer and share digital educational contents. In this way, a unique collaborative environment, which is full of shared resources, is growing. It is rather an e publishing system than a commonly known and used learning management system – LMS. Recently the development was focused on new interactive elements which are popular and well-known from the widely used social networks. Although it is not expected to move the portal platform into the world of social networks, the new interactive elements seem to be useful in keeping the contents recent and attractive. It is important to attract authors from clinical medicine. Therefore new tools which will provide publishing of casuistics are also in the development plan.

Keywords

e-learning, e-publishing, social networks, tag cloud, casuistics

Introduction

Recently, the majority of institutes and clinics in medical schools have prepared a large number of electronic teaching materials that need to be made available to students. Digital educational contents offer students information faster than printed materials – it is easy to update, what is especially important in medicine.

Production of electronic teaching materials is time-consuming. On the other hand, once electronic materials have been created, they further save time to teachers, who otherwise spend time preparing for repeated lessons. Experience from a project of the Charles University in Prague^[1], which dealt with the creation of comprehensive e learning courses in Moodle, shows that when teachers get a tool which enables their students to access free e-learning materials, then the teachers use this system provided that they receive technical support. Students appreciate

that they can better prepare for the subject as well as that they can access electronic materials also after completion of the course studied.

The use of information and communication technologies (ICT) in teaching of medicine and medical care has been frequently discussed on national as well as international fora^[2–5]. The idea of sharing educational digital contents among Czech and Slovak medical faculties appeared in 2006 for the first time. Early after that in 2007 all seven Czech medical faculties as well as all three Slovak medical faculties have formally joined the brand new network MEFANET (MEDical FACulties NETWORK)^[6–7]. One of its main objectives is enabling authors to publish their electronic teaching materials in a system without any licensing fees. The e publishing system consists of ten standalone educational portal instances, which are run on each of the participating schools,

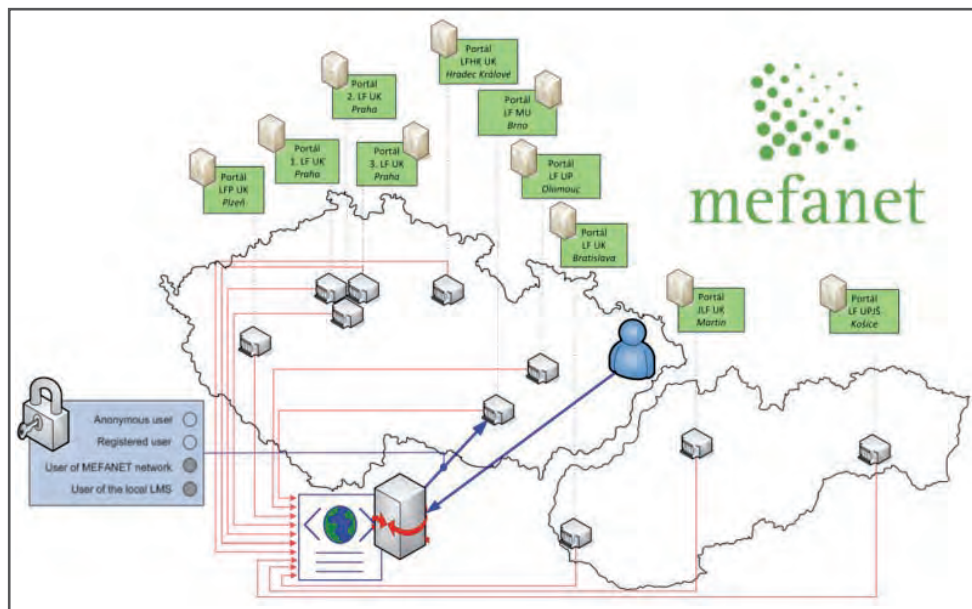


Figure 1. All seven Czech and all three Slovak medical faculties are joined in the MEFANET project (<http://www.mefanet.cz>). They share digital educational contents with the use of the common portal platform, which consists of ten standalone portal instances and one central gate.

and one central gate, which allows students to find study materials from all participating schools at once, see Fig. 1. The portal instances are connected to authentication services of the involved schools, so that students and staff do not have to define and remember ten new logins and passwords.

Fundamental elements in the MEFANET e-publishing platform

Scalability and extensive customizations are important and desired properties of the MEFANET e-publishing system. On the other side, there are also several legitimate requests for particular common conventions which should be followed on the parts of local administrators: 1. medical disciplines linker, 2. authentication/authorization framework, 3. digital contents quality evaluation.

Medical disciplines linker

Titles and topics of the contents sections as well as the types of the educational materials are arbitrarily configurable for each portal instance, whereas the medical disci-

plines linker is the only obligatory element for all the portal instances and the central gateway too. At the beginning single-level or multilevel list of medical specializations were considered as well as the possibility to adapt an existing scheme from the National library of the Czech republic, which is based on the standard Conspectus method [8]. However, the medical disciplines mapping according to the Conspectus method showed to be inapplicable for MEFANET purposes. Thus, an own medical disciplines linker was composed, based on various taxonomies adapted from significant medical publishing houses. Since its first release the linker has been reedited many times, see the current version in the tab. 1.

Authentication / authorization framework

The access to portal itself is not restricted anyhow. All pages and contributions at the portal are accessible for anyone. Thus, everyone interested can get an overview of digital educational contents available in the given medical school or even in the whole MEFANET network. The educational contents consist in a system of articles which

Table 1. The list of medical disciplines for basic categorization of the educational contents in the MEFANET project. Version: October 2010.

Anaesthesiology and Intensive Care Medicine	Anatomy
Biology	Biophysics
Cardiology, Angiology	Dentistry
Dermatology	Diabetology, Dietetics
Emergency medicine	Endocrinology, Metabolism
Epidemiology, Preventive Medicine, Hygiene	Gastroenterology and Hepatology
General Practice Medicine	Genetics
Geriatrics	Haematology
Health Care and Nursing	Histology, Embryology
Immunology, Allergology	Infectology
Laboratory diagnostics	Medical Ethics and Law
Medical chemistry and biochemistry	Medical informatics
Microbiology	Nephrology
Neurology	Neurosurgery
Nuclear medicine	Obstetrics, Gynaecology
Occupational Medicine and Toxicology	Oncology, Radiation Therapy
Ophthalmology and Optometry	Other
Otorhinolaryngology	Paediatrics, Neonatology
Pathology, Laboratory Medicine and Forensic Medicine	Pharmacology
Physiology and Pathophysiology	Psychiatry, Psychology, Sexology
Public Health Care	Radiology and Imaging
Rehabilitation, Physiotherapy, Ergotherapy	Respiratory Medicine
Rheumatology	Surgery, Traumatology and Orthopaedics
Urology	

describe the electronic teaching materials in detail, particularly by its title, short abstract and several other types of metadata. The educational contents itself is included in an attached files or hypertext links. Each attachment and/or link contains information on a group of users who have access to these materials.

The authors of the educational contents (published attachments) can choose from the following user groups, in order to permit/deny access to their materials: 1. non registered anonymous user, 2. registered anonymous user, who accepts the terms of use within his registration, 3. user of

MEFANET network, i.e. student or teacher from any Czech or Slovak medical faculty, 4. user of local university, whose affiliation to that university has been verified at the portal via the local information system of that university, 5. user of local medical faculty, whose affiliation to that faculty has been verified at the portal via the local information system of the respective university or faculty, 6. user to whom attachments are made available only on the author's explicit consent.

If the user's home institution (university / faculty / hospital) is member of the Czech academic identity federation eduID.cz,

the user's identity can be verified without his/her previous registration, using the service called Identity Provider operating at the side of user's institution: the user is only required to enter his login and password to confirm his/her affiliation to that institution. In particular, this option is available to users from five faculties at Charles University in Prague, Masaryk University in Brno and Palacky University in Olomouc. These institutions also provide the user's attribute MEFAPERSON during authentication procedures via Shibboleth technology. This attribute determines user's identity within the MEFANET network and authorization rules are derived based on its value on the side of the requested portal instance.

Digital content quality evaluation

There are two ways, how to evaluate quality of an article presented on the portal:

1. An opponency action. In the case of a pedagogy work which meets basic criteria set by an academic board of a faculty, the work is reviewed and then published with an icon of an editorial committee or another authority of that faculty. Besides the logo, there is also other information added, which give full contacts to the author as well as to reviewers.
2. Guarantee signatures. There are guarantees defined for each of the medical disciplines in the linker described in tab. 1. They are allowed to express their opinions and objections for each contribution assigned to their disciplines. Their voice can be of three meanings:
 - a. Accept – the contribution will be signed by a positive icon with an alternate text identifying the guarantee;
 - b. Reject – the contribution will be signed by a negative icon with an alternate text identifying the guarantee. The portal's administrator should discard this contribution from the medical discipline.
 - c. Undefined state – the contribution is not signed by any icon. Either it has

not been read by the guarantee or there are some insignificant objectives which do not imply discarding the contribution.

New components and interactive functionality

The generations of digital-native students use the Internet certainly not only in order to consume the presented information. The digital-native users of web applications increasingly expect a high level of interactivity, creativity and support for their cooperation. The recent developments of the common platform have been therefore focused on implementation of several important interactive components, described below.

Tag cloud

Tags, which are known from popular social networks (Twitter, MySpace, YouTube, etc.), can be sticked to the contents by users themselves without their prior authentication / authorization. Users have the possibility to spontaneously respond to the published teaching materials by marking it with their own tag or tags. The tag can be a word or a phrase. Adding a set of words (tags) for each piece of contents, an entirely new structure of the portal can be created. This new user-defined structure, usually referred to as "tag cloud", may change over time and has a form of a rather messy set of words – the size of the font indicates, how many times the tag was used, see the example in Fig. 2. The tag cloud implementation in the portal platform includes tools for convenient control of uppercase and lowercase letters in the tags sent recently.

Discussion forum

Each article describing electronic teaching materials can be provided by users' comments. Administrators can use moderation tools such as automated detection and censoring of swear-words with the use of a predefined dictionary. There were several cases where questions in the comments sec-

tion were sent by patients seeking further information regarding their health. Administrators should forward these queries to the authors and leave it on their decision whether they further communicate with patients or not. The discussion can be even disabled if there are no human resources to keep the discussion reasonable, polite and presentable.

User rating

Another option, how to express the quality of a published piece of educational contents, is using a rating scale. The scale is shown with five stars, while a half of a star is the smallest unit on it. Each article footer contains the overall average rating as well as the number of users who rated the teaching material. From a technical point of view it is worth to note that multiple ratings sent from a single computer are prevented as well as sending queries or ratings from crawlers and bots, which are programs that automatically scan the content of the Internet and click on everything. Discussion forums are further secured against spammers, who often use this type of forms for posting their links to various external web sites. The new interactive elements are implemented using AJAX technology (Asynchronous JavaScript and XML) together with javascript library JQuery. In this way rapid responses to users' actions are achieved, without

having to refresh the entire page in the browser.

Image casuistry

Findings of the conferences MEFANET 2007–2008 showed that a greater involvement of representatives of the clinical courses is limited by the fact that the creation of electronic teaching materials is very time-consuming. Arrangement of a clinical material, whether text, image, video or multimedia, is very long and arduous process of organization, which does not bring immediate results. There are known cases of large-scale multimedia atlases, but such extensive works are usually difficult to update and it is tough to initiate new ones. Moreover, it is and will always be more important for authors from clinics to publish scientific works in impact journals rather than to publish teaching materials in a shared e-publishing system. Therefore, the new version of the common portal platform offers quick publishing a new type of digital contents – image case reports. The body of each case report has an usual structure {examination, medical history, diagnosis, differential diagnosis, laboratory results, histology, imaging, therapy, comments}. This structure is a default one but can be modified to the needs of authors. A crucial role in this new type of contents play the attachments again, which are 2-D medical images such



as macroscopic photographs, microscopic photographs or images acquired with the use of modern medical imaging modalities. Tools for comfortable image viewing were adopted from already made image atlases^[9–10].

Conclusion

The basic ideas of the MEFANET project were explained here and the fundamental elements of the solution for the common e publishing platform were described. Students and academic staff can browse the teaching materials sorted by medi-

cal disciplines, authors, schools or quality evaluation criteria. There are sophisticated tools for searching in the complete database. Titles, keywords, abstracts other metadata and fulltext indexes are searched and the results are given to the user in the relevance-order.

New interactive components, which provide a wider user interactivity, were described as well as the recently implemented image case reports. Further developments in the common portal platform will lead to a richer array of tools for quality evaluation of the digital educational contents.

References

1. Feberova, J. et al.: Evaluation of 5-year Experience with E-learning Techniques at Charles University in Prague. Impact on Quality of Teaching and Students' Achievements. In The New Educational Review, ISSN 1732-6729, 2010. vol. 21, no. 2, pp: 110–120.
2. Schwarz, D. (ed.), Dušek, L. (ed.). Report RITM: Informační technologie a telemedicína ve výuce klinických a zdravotnických oborů. Brno: Masarykova univerzita, 2005. 101 p. ISBN 80-210-3924-8.
3. Schwarz, D. (ed.), Dušek, L. (ed.). Report RITM II: Moderní metody výuky lékařských oborů pomocí informačních technologií a telemedicíny. Brno: Masarykova univerzita, 2006. 105 p. ISBN 80-210-4213-3.
4. Dušek, L. (ed.), Mihál, V. (ed.), Štípek, S. (ed.), Potomková, J. (ed.), Schwarz, D. (ed.), Šnajdrová, L. (ed.), Štuka, Č. (ed.). MEFANET report 01. Edukační sborník – 1. celostátní konference lékařských fakult ČR na téma e-learning a zdravotnická informatika ve výuce lékařských oborů. Brno: Masarykova univerzita, 2008. 211 p. ISBN 978-80-210-4539-2.
5. Schwarz, D. (ed.), Dušek, L. (ed.), Štípek, S. (ed.), Mihál, V. (ed.), Paton, C. (ed.). MEFANET report 02. Information technology and e-learning in medical education. Brno: Masarykova univerzita, 2009. 125 p. ISBN 978-80-210-4851-5.
6. Project MEFANET: MEDical FACulties Educational NETwork [online]. [2007] [cit. 2010-10-12]. Available: <http://www.mefanet.cz>
7. Dušek, L. et al.: MEFANET: a collaborative project of the Czech and Slovak medical faculties for development of a joint educational network In MEFANET report 01. Brno, 2008. ISBN 978-80-210-4539-2, pp:13–16.
8. Stoklasová, B.: Conspectus Method Used for Collections Mapping and Structuring of Portals [online] [2006] [cit. 2009-04-12]. Available: <http://info.jib.cz/dokumenty/helsinkistoklasovatest.pdf>
9. Schwarz, D., Penka, M., Dušek, L., Brabec, P.: TELEHEMATOLOGY – ICT Solution of a Shared Digital Image Repository. In Proceedings of the First International Conference on Health Informatics HEALTHINF 2008. Funchal, Madeira – Portugal : INSTICC Press, 2008. ISBN 978-989-8111-19-7, pp.168–171.
10. Feberová, J.: CASEMED – virtual library of information resources. ISSN 1801-724X.

E-LEARNING PORTAL OF SLOVAK MEDICAL CHAMBER

Meško D., Dragula M., Jurigová M., Turček M., Žúbor P., Teremová Z., Gajdošík J., Samek P., Stuchlíková L., Ďurišin M.

Jessenius School of Medicine Comenius University, Martin, Slovak Medical Chamber, Bratislava, Slovakia

Abstract

Slovak Medical Chamber (SMC) applied a project proposal to Ministry of Health of Slovak Republic and received a non-repayable financial contribution from European Social Fund in Operational Program Education for the project: Formation and implementation of e-learning portal for medical education. Project background was coming from a systemic coordination of continuing medical education need for Slovak doctors and for an accessibility and flexibility of educational activities for them. The project will apply up-to-date technologies in the form of e-learning portal through which an increased availability and current information for target group in digital form will be provided. Web page www.i-med.sk for doctors will not replace present modes of medical education, it will complement them. Portal will provide user friendly smart tool for continuing education and self-education. E-learning portal as the tool: * for educational activities coordination of SMC; * for education of doctors – excerpts from educational activities will be prepared in the form of e-learning (text, audio, PowerPoint presentations, multimedial videosequence from scientific events); * for self-testing, testing and credit awarding and evidence; * for the scientific information acquisition and exchange – virtual library; * for the e-learning papers preparation and foreign papers translation. Entrance analysis of project consisted of from three partial analyses: 1. Analysis of existing medical portal in Slovakia and abroad; 2. Analysis of continuing medical education in Slovakia; 3. Analysis of doctor demands in the area of continuing medical education. A questionnaire about the actual status in the area of digital medical education in Slovakia was a part of entrance analytical phase of project.

Keywords

e-learning, continuing medical education, European Social Fund

Introduction

Slovak Medical Chamber (SMC) prepared in the years 2008–2009 and applied in the year 2009 a project proposal to Ministry of Health of Slovak Republic and received a non-repayable financial grant from European Social Fund in “Operational Program Education”, priority line 2 – “Continuous education as a tool for human resources development” for project: Formation and implementation of e-learning portal for medical education. Project background was

coming from a systemic coordination of continuing education need for Slovak medical doctors and for an accessibility and flexibility of educational activities and methods for them. The project will apply up-to-date technologies and methodologies in the form of e-learning portal through which an increased availability and current information for target group in digital form will be provided. Web page www.i-med.sk for doctors will not replace present modes of medical education, it will complement them. Por-

tal will provide user friendly smart tool for Continuing Medical Education (CME) and self-education.

Why the e-learning portal

Today education paradigm has changed fundamentally and has shifted into a new qualitative and quantitative position in today global world digital environment and reality. Educational information are today everywhere 24/7/365. Information is a gold mine in today world, but still (almost) “free of charge”. They are available anywhere, anytime to anybody. Many times it is a matter of capturing them from the “air” via digital communicator; it is enough to pick e.g. an iPhone from pocket, or to google them via notebook, PDA ETA. Information-communication technologies (ICT) are the tools; they are upgraded, new form of chalk and board. These tools are not changing the education content. Relevance, credibility and content of information remain a gold standard for medical communication and information sharing. In the era of contemporary information flood there is a strong need and must to manage them to prevent information chaos and overload. And secondly the need and must for validity and credibility of information alone and/or the original information source. Internet and information in it are our external hard-disc. Online education (direct, live) is a modern manner of education and credit acquisition from home, working, business or other environment via internet resources with use of computer. These were the reasons the Slovak Medical Chamber decided to prepare and offer this tool and method for up-to-date medical education to clinical community of medical doctors.

Project scope

Project of e-learning portal consists of compartments, main and partial goals. They also resulted from the analysis of target group of health workers needs and requirements. The aim of Continuing Medical Education (CME) is a life-long access to

scientific medical information and to motivate them for their receiving and studying. In Slovakia there is no compact system of CME at present which would provide the tool for the continuous receiving of medical information sorted in standardized sets. Primary goal of project is the construction of e-learning portal and its use in the CME. There is another ambition of project, to contribute to education support of health workers in connection with legislation changes and health care system restructuring. Project will also implement the educational innovations and increase of CME system quality in digital environment. Specific project goals include: 1/ analysis of existing CME and e-learning systems used in Slovakia and abroad, 2/ construction and implementation of e-learning portal as a up-to-date tool for medical education, 3/ training of e-learning portal users, 4/ creation and continuous updating of e-learning portal content.

Actual situation

In the era of classical educational space by means of congresses, seminars and other professional events as one of the education form there is a great portion of scientific events that are linked closely to pharmaceutical industry. This situation is affecting logically both formal and contentual parts of meetings. These types of scientific events often modify the scientific and professional qualities of lectures. Congress participation is financially and time demanding frequently. The physician is many times obliged to arrange a substitution in his/her work. Congress participation does not mean new medical knowledge acquisition automatically. There is no system there of knowledge checking received during the medical educational events. Sometimes the motivation of event attendance is not the educational/scientific content, but more frequently the personal (face-to-face) formal social contacts with colleagues. These are, of course, still very important during medical events; they are irreplaceable and can-

not be substituted through computers. On the other hand there are great portions of medical educational events and their content (in some cases) linked only to a narrow spectrum of daily medical practice activities of physician like focusing only on a part of therapeutic modes through specific pharmaceutical medicaments. Medical educational events are far less frequent consisting of all and balanced spectrum of medical care practice content (including pathophysiology, pathological anatomy, diagnostic procedures, differential diagnosis, prevention etc.) to receive holistic and broad-spectrum of information needed (even vital) for his/her practice. The ratio of original medical scientific lectures presented at medical events is diminishing, review paper presentations are increasing, but pharmaceutical symposia with clinical trial results of drugs are significantly increasing.

Entrance analysis of project

Analysis consists of three partial analyses: 1. Analysis of existing medical portals in Slovakia and abroad; 2. Analysis of continuing medical education in Slovakia; 3. Analysis of doctor demands in the area of continuing medical education. A questionnaire about the actual status in the area of digital medical education in Slovakia was a part of entrance analytical phase of project. Project team has taken into consideration that 54% of medical doctors in Slovakia are in the retirement age and still working; so not all of them will be able and motivated to use actively the information and educational possibilities offered through e-learning portal. Only 8,000 medical doctors in Slovakia have internet access with parameters needed for e-learning portal use. To the other obstacles belongs the willingness for education, because many of them have the “digital literacy” experience only (computer and very basic programs handling), but only few of them are at the level of “digital skills”, so they know how to work with internet resources, or are using PC software creatively.

Questionnaire survey

During the analysis of GPs ($n = 948$; $M = 425$, $F = 523$) practical needs we performed a questionnaire survey (July-August 2009). 97% of respondents were internet users. The aim of survey was the analysis of the questions asked 1/ what is the system of CME of physicians and what is missing in education, 2/ what would motivate the physicians to visit e-learning portal. Physicians specified their answers: 1/ 77.2% were digitally skilled; 2/ most common access to internet was from home followed with job environment; 3/ the highest volume of continuous education assigned workers in laboratories (30 hrs/month), followed with medical schools, hospitals and ambulatory institutions (12 hrs); 4/ sources of medical information were: medical journals, conferences, followed with internet portals; 5/ the most visited web-portals were: PubMed, Google, Medscape, Emedicine, Slovak Medical Chamber; 6/ reasons of web-portals visits were: up-to-date information ($n = 183$), specific selection of medical information, online access, extent and multidisciplinary of information ($n = 83$); 7/ educational areas not covered sufficiently: internal medicine (25.4%), diagnosis and therapy, neurology and psychiatry, pediatrics (9.3%); 8/ motivation to visit e-learning portal: up-to-date information (highest ranking), extent of information, user friendly education; 9/ new portal content preferences: guidelines (highest ranking), autodidactic tests (and credits award, interactive papers, review articles.

E-learning education advantages

Medical doctor is studying, checking his/her knowledge and gather credits through autodidactic tests in his/her free time and when he/she likes it. Medical doctor is studying at his/her own pace. He/she is not obliged to travel anywhere and to look for colleague substitute in his/her ambulance and can study at home, in working place, or

other place. In on-line system of study there are plenty of medical information resources; doctor can choose the needed and actual only.

E-learning portal as the tool

E-learning portal will function for educational activities coordination of SMC – all educational activities organized by SMC will be announced in portal (place, time, program, lecturers etc.); for education of doctors – excerpts from educational activities will be prepared in the form of e-learning materials (text, audio-Power-Point presentations, multimedial videosequences from scientific events, guidelines); for self-testing (autodidactic tests), testing and credit awarding and evidence; for the scientific information acquisition and exchange – virtual library with top full-text journals; for the e-learning papers preparation and foreign papers commented translation (excerpta).

Tools for users and reviewers

Project team will prepare templates and manuals for all educational materials preparation (professional papers, commented translated papers, e-learning courses materials, abstracts, review templates, text + photos + graphs + audio-recordings + video-recordings, internet links etc) which will provide standardized structure and format of materials for all.

Project activities performed in the first months

Except the above mentioned introductory analyses, project team performed activities in the area: questionnaire investigation amongst 948 medical doctors in the area of CME and ICT use; content feature of portal; distribution of each subject on portal; safety and protection of patient; credit acquisition and assigning + legislation update; preparation of the system of author and reviewer teams; preparation of the portal editorial board; testing of Audience Response System in medical events.

Conclusion

Project background was coming from a systemic coordination of continuing medical education need for Slovak doctors and for an accessibility and flexibility of educational activities for them. The project will apply up-to-date technologies in the form of e-learning portal through which an increased availability and current information for target group in digital form will be provided. Web page www.i-med.sk for doctors will not replace present modes of medical education, it will complement them. Portal will provide user friendly smart tool for continuing education and self-education.

References

1. Meško D., Dragula M., Jurigová M., Turček M. (2009) “E-learningový portál Slovenskej lekárskej komory”. [Online]. Available: http://www.mefanet.cz/res/file/mefanet2009/prispevky/mesko_full.pdf

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WIKILECTURES – AN INSTRUMENT OF MEFANET NETWORK BASED ON TECHNOLOGIES OF WEB 2.0

Vejražka M., Štuka Č. and Štípek S.

Charles University in Prague, 1st Faculty of Medicine

Abstract

Since 2006, network of medical faculties MEFANET arose and gradually expanded, aimed to efficiently share teaching materials. It was managed to achieve this goal thanks to web portals of all faculties and a common internet gateway. Medical teaching materials are shared among medical faculties of the Czech and the Slovak Republic, and they are also created together in an extent that could be the envy of others. The word MEFANET gradually became a synonym for the common gateway of medical faculties. Portal-based solution of MEFANET network has continuously developed and perfected throughout its existence. However, at the same time, also the environment in which MEFANET lives – the whole world of information technology, changed. The rapid development of IT is now becoming a challenge for MEFANET: students and teachers of medical faculties, MEFANET network users, are also users of many other services available on the internet. When they find any useful and convenient tool in the global network, they quickly get used to it and will expect the same level of comfort and service from MEFANET.

Shift in the world of information technology in recent years has been dramatic. At the time when basic ideas of MEFANET emerged, ideas of Web 2.0 started to be distinguishable in the mainstream of development of IT. Although the designation "Web 2.0" may not be familiar to everyone, technology hidden behind it is used by each of us.

The advent of Web 2.0

The term Web 2.0 was first used by Darcy DiNucci in 1999 in her article "Fragmented Future" ^[1]. Wider recognition for this concept came five years later, thanks to Tim O'Reilly and the Web 2.0 conference ^[2, 3]. In the Czech Republic, the term Web 2.0 became frequently used since 2006.

From the "old" web, the Web 2.0 differs mainly in roles of authors and web users. While the classical approach distinguishes authors – content creators and readers – users, this division of roles in the Web 2.0 changes. The user is drawn to the creation of content and the author has created a working framework only. Typical tools of Web 2.0 include user content rating, commenting and editing it, and inserting new content (text, blogs, photos, etc.). At the

same time, interaction between users is promoted. The use of tools and ideas of Web 2.0 leads to formation of social networks. The participants communicate with each other and together form the content. Social interaction gets users involved, encouraging them for further work and so it plays an important role in the dynamics of the entire web. Note the crucial differences from the previous concept, which has always had an authority – guarantor of the content. It could be an individual, institution or group of experts. However, knowledge of the best expert or even a group of experts is always limited. The limits of human knowledge have been pointed out as early as in 1945 by an Austrian liberal economist FA Hayek in his work *The Use of Knowledge in Society* ^[4]. He showed that the information is necessar-

ily dispersed among many subjects and it is not possible any individual to encompass it all.

Openness versus closeness

The ideas of Web 2.0 are projections of the new approach, of new visions to the world of web. Same thoughts however appear also in other areas of our lives.

Development of applications for mobile phones may serve as an example. Building applications for iPhone, the company Apple hoped in creativity of users. The company prepared an open environment and provided resources. Wide range of applications was then created by users. With the same vision, Android, the mobile phone of Google, was launched into the world. Other platforms such as Symbian and Windows Mobile did not catch the onset of this approach and their market began to decline^[5]. To better illustrate the changes, it can also be noted that Nokia released the mobile operating system Symbian as open source, hoping in faster development of the system.

What are the characteristics of Web 2.0 ideas in the world outside the web? These are openness, promoting creativity, and initiative coming from the "bottom". Simply said, open concepts show certain internal dynamics (the "live"). By contrast, closed concepts are "dead", static (the development must be stimulated from "above"). In an open system, everything is permitted if it is not explicitly prohibited. In a closed system, by contrast, everything that is not allowed is prohibited. These rules are general and are reflected outside the world of web.

What are differences between the old and the new concept of web

Here are differences between "old" and "new" web on several examples.

Comparison of "catalogues" and "full-text search engines" in organizing and finding

information on the web may serve as the first example. Catalogues are (were) structured databases of links, where the validity and order of links were determined by the site owner, represented by a team of experts. In the early days of the internet, all searches were based on the catalogues; e.g. Yahoo originally worked as a catalogue.

Many younger internet users have never get in touch with catalogues. Catalogues gradually disappeared completely – in the evolution of web tools, they have been completely displaced by full-text search, in which the relevance and ranking of links is based on preferences of many people, not on any well-intended decision of any authority.

The second example showing the shift from knowledge guaranteed by authority to the knowledge guaranteed by users is comparison of the quality of Wikipedia and Encyclopaedia Britannica by the journal Nature^[4]. In 2005, reviews by leading experts were comparable in both cases – both encyclopaedias contained the same number of substantial errors, in Wikipedia reviewers found a few more minor factual mistakes. While the Encyclopaedia Britannica had to wait until the next edition with rectifying them, Wikipedia was corrected immediately. It should also be taken into account that since 2005 Wikipedia has undergone massive growth (while the extent of Encyclopaedia Britannica is substantially unchanged), and it became the most popular source of information today.

Technology Web 2.0 and MEFANET

Development of the portal of the MEFANET network responded to the need for continuous interaction with the user – elements of Web 2.0 were introduced into it. Comments can be added to individual educational materials, creating feedback between the reader and author. Materials can also be evaluated using the "stars" and thus information about their quality is shared among users. The portal also has new features of

personalization. It "remembers" the last viewed material and clearly offers it to the user in the time of the next visit.

Relatively new is the ability to mark materials with "tags", a kind of keywords created by users. The most frequently occurring tags will appear as "Tag Clouds", allowing searching for "hot" topics that are most read by users.

WikiLectures – a new tool of MEFANET Network

Portfolio of e-learning tools for medical schools is now expanded with new, technologically advanced device – WikiLectures (WikiSkripta in Czech language, www.wikiskripta.eu). It is a web repository of medical teaching texts based on one of Web 2.0 technologies, wiki. It is very easy to create, edit and update teaching materials in WikiLectures. Compared to other instruments, WikiLectures facilitate collaboration of multiple authors. WikiSkripta also allow an already created text to be easily taken and incorporated it into a wider article. WikiLectures were established for MEFANET at the 1st Faculty of Medicine, Charles University in Prague, in 2007. After a period of technical development, they have been opened to all medical faculties of the Czech and Slovak Republic since the end of the year 2009.

Basic properties of wiki

Wiki is designed for creating and storing texts, illustrated with figures and some other file formats. It uses a very simple language for text formatting, creating links and maintaining the structure of pages. Wiki is mostly known to the general public thanks to Wikipedia, an opened web encyclopaedia that can be edited by anyone. Editing in wiki is so easy that each user can handle the first steps by himself at the first attempt.

In principle, different types of access permissions are not distinguished in wiki: anyone can create new posts and edit existing ones. Only a small number of administra-

tors require special rights, necessary for really technical interventions only. In practice, it appears that despite the large openness, information in wiki-projects is quite reliable. Well-known study on reliability of Wikipedia^[4] has already been mentioned. The security and reliability is guaranteed in two ways. First, by technology. There are tools that allow any possible "wiki-vandalism" to be combated effectively. The second aspect of protection is sufficiently large number of active users (so-called supercritical number). Once the number of users has exceeded this boundary, inaccuracies and errors are amended very quickly.

WikiLectures are not Wikipedia

Although WikiLectures and Wikipedia have many common principles, use the same engine, and it can even be said that Wikipedia is inspiration to WikiLectures in many ways, there are fundamental differences between these two projects. Wikipedia is an online encyclopaedia. Articles in it must comply with the encyclopaedic style; each contribution must be understandable separately to the reader. Texts in Wikipedia should be accessible to a wide audience. WikiLectures are, by contrast, an internet textbook covering a specific area – medicine. Some prior knowledge may be required to understand a particular text. Authors may assume that the student will read "chapters" in a certain order. Contributions may also be more detailed than that in Wikipedia. It is a teaching text, which does not respect the boundaries of individual subjects taught. In WikiLectures, it is necessary to maintain a certain "learning objectives", with which the material is offered to the reader.

Involvement of students

The authors of WikiLectures are not only teachers – quite the contrary, a number of quality texts are inserted by students. Teachers can use it later for processing

larger chapters, may correct it, sort it, etc. However, involving students in WikiLectures goes much further. The students of medical faculties constitute the greater part of the technical editorial office – a team that maintains the structure WikiLectures, helps novice authors to adjust the text, adapts the user interface, etc.

Verification articles

As we noted earlier, the accuracy and credibility of contributions to WikiLectures is ensured by the technology to a large extent. In order to further increase the reliability of the texts in WikiLectures, a tool for verifying the quality of articles by teacher was introduced. Educators of medical faculties can check the texts and “sign” an established way. Information about verification clearly appears in the header of the article. It is however still possible to edit the article. But, once it has been adapted, information about verification in the header of the article is changed, so that the reader is informed that the current version differs from the proven one. A single click can return the reader to the checked version, or to a comparison chart displaying the differences between actual and checked version. Moreover, both author of the article and teacher who checked it receive automatically notification about changes.

WikiLectures among other instruments of MEFANET network

Birth of WikiLectures brought to the students and teachers a powerful, yet simple, easily accessible and safe tool for the creation of teaching materials based on texts. Especially for text documents, the wiki technology is extremely beneficial, as com-

pared with traditional methods (using a text editor, distribution of materials in the form of pdf files, etc.). Wiki facilitates cooperation of authors, amending and updating the text. Moreover, the resulting document is immediately accessible to readers. On the other hand, compared to other instruments, there are also some limitations of WikiLectures. For example, current technology does not allow controlling access to sensitive material, which is sometimes necessary for medical education. Despite this fact, WikiLectures become not only a complement to other e-learning tools, but they are in some respects even superior. Their great potential can be documented by the strong and sustained growth of the number of contributions: after a year and a half of operation, 1500 articles were posted and more than a hundred are inserted every month. In the last year, WikiLectures encountered more than a million of accesses. Another fact demonstrates growing reputation of WikiLectures: the search engine Google ranks medical texts from WikiLectures often among the first results – despite their short existence. This means that articles of WikiLectures are popular, often more than comparable texts in other sites. We believe that WikiLectures may soon become a major tool for production and dissemination of electronic medical teaching texts.

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References

1. DiNucci, D., Fragmented Future, Print, 53 (1999): 32. [available online] <<http://www.cdinucci.com/Darcy2/articles/Print/Printarticle7.html>>
2. Paul Graham, Web 2.0, 2005, [available online] <<http://www.paulgraham.com/web20.html>>
3. Tim O'Reilly, What Is Web 2.0 O'Reilly Network, 2005-09-30, [available online] <<http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html>>
4. Friedrich A. Hayek: The Use of Knowledge in Society. American Economic Review 35 (1945): 519–530, [available online] <<http://www.econlib.org/library/Essays/hykKnw1.html> Czech: <http://nb.vse.cz/~freedom/>>
5. Gartner, Inc., Gartner Says Worldwide Mobile Phone Sales to End Users Grew 8 Per Cent in Fourth Quarter 2009; Market remained flat in 2009, 2010-02-23, [available on-line] <<http://www.gartner.com/it/page.jsp?id=1306513>>

MEDICAL E-LEARNING AND TESTING SYSTEM POWERED BY CROWDSOURCING AND BASED ON SOCIAL NETWORKS DESIGNS

Thurzo A.¹, Makovník M.², Lysý J.¹, Valkovič L.³, Javorka V.¹

¹ Department of orthodontics, Clinic of dentistry and maxillofacial surgery of Medical faculty Comenius University and St. Elisabeth Institute of oncology, Bratislava, Slovakia

² 2nd Department of Internal Medicine, Medical faculty Comenius University and Faculty hospital in Bratislava, Slovakia

³ Department of radiology, St. Elisabeth Institute of oncology, Bratislava, Slovakia

Abstract

Three years of development of on-line e-learning and testing system adapted on medical students' and teachers' needs, resulted into current on-line project called Opus Sapientiae. It represents a smart on-line examination system, which takes advantage of crowdsourcing. Crowdsourcing is an answer for many other good on-line projects gaping with emptiness in a desperate need for further content. Opus Sapientiae does not concentrate on the education but rather verification of the knowledge although it represents a complex tool for building, editing and application of its content. It allows wider freedom to students in choosing the form and way of learning. The basic premise is that complex knowledge of a particular topic could be divided into finite number of facts. Facts those acquaintances could be uniquely determined. System with a few simple features avoids some negative effects in medical education: mechanical memorizing, learning "to pass the exam", distinction of importance of various facts, non-evidence-based dogmas. It is designed to be intuitive with intentional similarities to some of the most popular social networks.

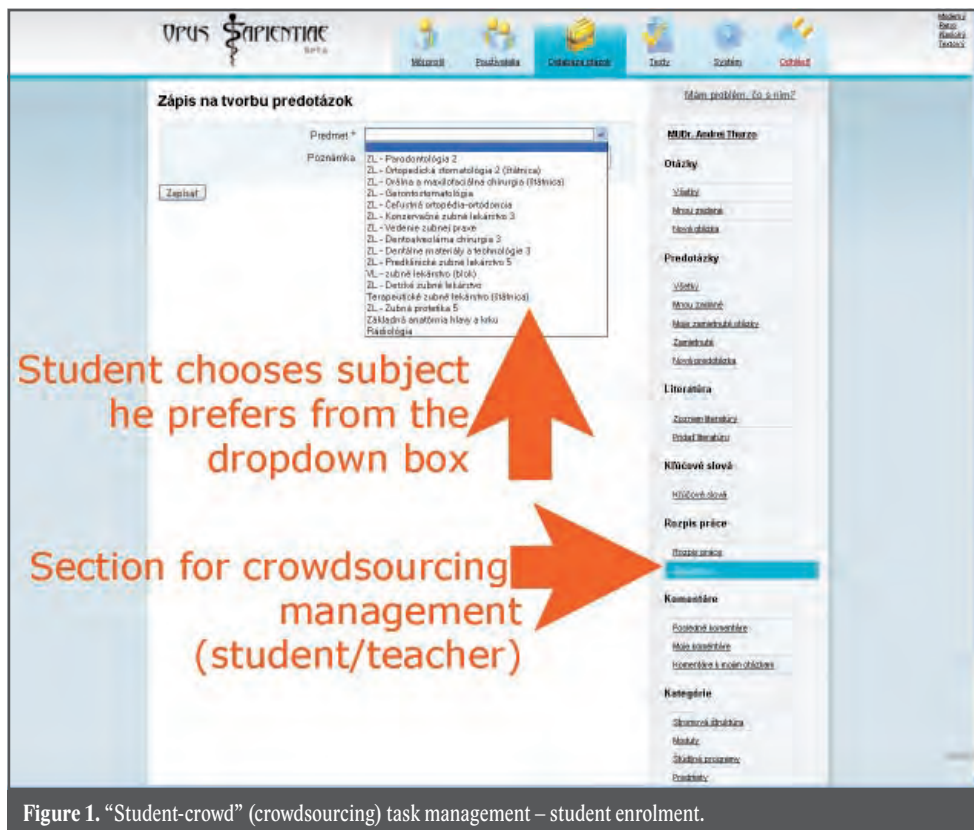
Keywords

e-learning, medical education, crowdsourcing, on-line examination, test

Introduction

Current e-learning efforts of most of the academic institutions concentrate on innovation of teaching methods, transfer of old non-digital content to cyber-world. Old papers, pictures, photos, analog x-ray and lectures are converted into digital format. The creators of the project Opus Sapientiae were formerly frustrated from enormous and uncompetable funding of foreign universities in creating of eContent. Teams of animators, coders, graphics, flash-creators and other developers were truly uncompetable in the amount and quality of the output. The role of mere translators of foreign eContent was also boring. Realization

of the fact that university students are everyday more and more aware of the on-line educational content, able to speak foreign languages and able to search and choose the most understandable source explaining the desired information, the production of eContent started to seem obsolete. With a true respect to teachers – who struggle and create eLearning content, the creators of Opus Sapientiae chose a different path. To accept all worldwide sources and let the students to chose their way. The student still has a list of recommended literature and also lectures at the university. The knowledge covered with them is compulsory; however nobody is forced to learn in a particular



way. To accept the change of paradigm shift in education and accept the position of the lecturer as leader who guides and recommends, who helps to understand and see the connections between facts and the one who encourage to think. Not the one who is supposed to support students with the background papers that they are supposed to learn, the one who is supposed to create the content by himself. These are the things he could do, but where the difference is often forgotten is that we don't want the student to learn the facts the way we want, but we want student to know and understand the facts no matter the way he gains them. If it is not our boring 2D PowerPoint that made him understand the differences between LeFort fractures but a YouTube animation somewhere from North Carolina university, does it matter? But what if he learns it wrong? What if the students use the unreliable Wikipedia? Why they even Google for knowledge? It is because we will be never able to make complete coverage for a topic

as the research goes on. Also do the web sources improve and advance. We will never be able to make our lecture or text so universal that suits everybody. And of course student instinctively search for the easiest way to learn the problem. Even if it is so simplified that it is actually wrong.

So what if students get it wrong? These are the real risks of letting students use complementary web resources. And here comes the role of this project. The position of mere translators of foreign eLearning content was boring and humiliating. The perspectives and volume of the eContent resembled a supernova however there was still one narrowing left. The stream of pre-exam and further post-exam education was due to the web too massive to be reasonably controlled, widening every day. The sorting and filtration of the web sources would be an infinite and difficult task with a questionable effect. The only narrowing of the stream, where everybody must go through, was the exam itself. Here was identified the opportunity to

Rozpis práce

Zoznam celotabulí

Filtrovat

(4) Radit vzostupne podľa

Meno	Príhlastie	Rokník	Predmet	Kniha	Strany	Poznámka	Koordinátor
Andrii Thoma	2010-03-04 19:41:20	3	Pednológia	IMBA TUMBA	20-66	ale rycitn	MUDr. Jura Lysy
Andrii Thoma	2010-03-04 19:42:25	3	Terapeutické zubné lekárstvo (šitárka)		2		MUDr. Andrii Thoma
Jura Lysy	2010-03-04 22:45:31		ZL - Parodontológia 2				
Jura Lysy	2010-03-04 22:45:47		ZL - Parodontológia			geordina	

(4) Radit vzostupne podľa

Student subject tutor accepted

Mám problém, ři s ním?

MUDr. Jura Lysy

Otázky

Všetky
Mojí zmluvy
Mojí otázky

Prednášky

Všetky
Mojí zmluvy
Mojí zmluvy otázky
Zmluvy
Mojí zmluvy

Literatúra

Zoznam literatúry
Podľa literatúry

Kľúčové slová

Všetky slová

Recpis práce

Zoznam práce

Komentáre

Podľa komentára
Mojí komentára
Komentára k mojím otázkam

Kategorie

Stomatologická
Mojí
Stomatologická
Mojí

Figure 2. “Student-crowd” task management – tutor defines the book, page range and all else writes as comment if necessary.

Zoznam cvičných testov

Filtrovat

(4) Radit vzostupne podľa

Názov testu	Nastavenia	Popis testu	Počet otázok	Spôsob testovania	Ukazateľ odpovedí	Aktualizácia	Spôsob odpovedí	Dejiny testu	Dejiny testu	Dejiny testu	Dejiny testu
ENGLISH - 4th year - general medicine - dentistry block exam 100 questions, brainstorming	100 / smer / rok / otázok 100 / čas 10 min	od 21.9.2009 10 questions, 10 minutes, 5 answers. 50% from - RukM / zubné lekárstvo_pre_40 10% from - RukM / anatomia_hlav_9_klju	100	Spôsob testovania	Ukazateľ odpovedí	1994	Spôsob odpovedí	Dejiny testu	Dejiny testu	Dejiny testu	Dejiny testu
4r. VL - stomatológia - 300 otázok predkyskový brainstorming	100 / smer / rok / otázok 300	od 21.9.2009 300 otázok, 5 možností, bez časového limitu s animáciami a videom. Po jednej otázke, 90% otázok z - RukM / zubné lekárstvo_pre_40 10% otázok z - RukM / anatomia_hlav_9_klju	300	Spôsob testovania	Ukazateľ odpovedí	1994	Spôsob odpovedí	Dejiny testu	Dejiny testu	Dejiny testu	Dejiny testu
300 questions - 4th year - general medicine - block exam from dentistry	100 / smer / rok / otázok 300		300	Spôsob testovania	Ukazateľ odpovedí	1994	Spôsob odpovedí	Dejiny testu	Dejiny testu	Dejiny testu	Dejiny testu
4r. VL - stomatológia - 300 otázok predkyskový brainstorming	100 / smer / rok / otázok 300		300	Spôsob testovania	Ukazateľ odpovedí	1994	Spôsob odpovedí	Dejiny testu	Dejiny testu	Dejiny testu	Dejiny testu

(4) Radit vzostupne podľa

Mám problém, ři s ním?

MUDr. Jura Lysy

Testy

Cvičné testy
Oficiálne testy
Nové cvičné testy
Nové oficiálne testy
Zoznam mojích testov

Súbory testov

Zoznam súborov
Nové súbory

Figure 3. The sortable list of non-official tests with first test expanded by upper right “+”, showing flag of the test language, number of questions, the way of testing and average age of the test’s source literature.

Figure 4. screen for creating a new test showed in modern design.

of the smart on-line system fight with some of current negatives in medical education: mechanical memorizing, learning “to pass the exam”, distinction of importance of various facts or non-evidence-based dogmas. Opus Sapientiae has many features. If it should be described by one sentence from aspect of use, its closest definition would be: “web application able to test, teach and create its contents as you desire by who you want”. If should be described simply from

a rather technical aspect it could be called as “PHP application on autonomous server with web 2.0 features”. Except for many possible uses it was designed for testing the knowledge with multiple-choice tests. Not necessarily the way you imagine multiple-choice test. The questions and answers could contain or be substituted with pictures, videos, animations or sounds. Most of its unique properties rely on vast amount of questions in the database. Because of this, one of the most important features are the tools for creating these questions. How to create huge numbers of non-repeating questions covering every fact in particular topic is explained by crowdsourcing. The crowdsourcing is described later in the text and for the project is crucial. The project allows creation of its content in various language mutations.

OPUS SAPIENTIAE

Academic network versus social network

Internet was a new opportunity for education maybe 10 years ago. Now, it is just a must. Young people “living” on social networks like Facebook or MySpace is a current reality with an intensively growing trend. Research published in 2009 by Nielsen [4] shows time spent on Facebook increased up by 700%. Growing tendency is well known however this number from the last year is kind of staggering. The numbers increase not only in the number of users but also increases the time spent in these networks for each user. The amounts of content users create or upload also increases. The Opus Sapiientiae has many similarities with social networks although not for the same motives. As the social network designers every day develop more and more sophisticated designs to draw their users to the network more often and for a longer time, the networks slowly became a huge “time-spender”. The academic e-learning networks will be the opposite. Trying to sup-

port requested information as quickly as possible concentrated on its aim (teaching, testing etc..). However the ways of building a crowdsourcing army of students, teachers, alumni, specialists and others, will be similar to common social networks. If we call such an army for example an “academic social network” it has poor chances in competition with giant projects like MySpace or Facebook. The best way is adaptation. Avoiding creating barriers between mostly entertaining networks and academic networks, there is a chance to create dedicated social network ready to make a “big things”. Implemented features common in current social networks are necessary for easy orientation and crowdsourcing activities of its users.

Basic blocks of the system

The system has upper and right side menu. The system was recently moved to a new server and two redirections will be ready to enter the system. www.opus.sapiientiae.ae and www.sapiientiae.ae The first redirection will lead you to an info page about the project and all the articles written about it, manuals and instruction videos. The second links directly to Opus Sapiientiae login site. Both redirections are based on Arabic domain with strict policy against pornographic or religiously offensive content. The reason of this is the project later ambition to spread and become multilingual with no affinity a particular country. Server is placed in Bratislava with sufficient up/down bandwidth. Before login there is an intro page with a brief info what is currently going on in the system. There is the upper menu allowing you to log-on, register or go directly to official tests. If you go directly to official tests section you will have to log-on or identify with an ISIC/ITIC card number. After entering the user sees only the part of Opus Sapiientiae with official tests without any other distraction by other system features. This is suitable for official student testing. Registration is necessary when you wish to create your account. If you wish just to

test yourself you could go directly to official test section and identify yourself with ISIC/ITIC card with no other harassment. Otherwise the registration process requires your personal data. In the registration form you select your role in the system (student/teacher etc.), these could be accepted automatically if you choose student or teacher role that is confirmed by university servers according you ISIC/ITIC card number. Automatic acceptance depends on the system settings adjusted by admins. Other roles with higher rights like power-user or administrator could be arranged only by other administrator. Registration ends with an activation email sent to your address and is automatic. Immediately you can start using the system.

After login to the system in a normal way the menus are depending on the rights your role has. There is an upper and right-side menu. The upper menu is the main menu and allows you to access 5 main sections:

1. My profile;
2. Users;
3. Database of questions;
4. Tests;
5. System.

There are 4 different designs of the system: modern, retro, classic and non-graphic. The systems' content is represented mostly by pre-questions, questions and tests. The pre-question is more than simple text with question mark at the end. It contains:

1. expression of the question (text or media = pic/foto/anim/movie/flash/sound);
2. expression of the question in English mutation (text or media);
3. optional // source of the multimedia (copyright if any);
4. optional // explanation is an author comment invisible during testing (text);
5. optional // language mutation of the explanation (text);
6. regular literature reference (text);
7. proposer – is filled automatically, although can be changed;
8. Keywords (text separated by commas);

9. english mutation keywords (text separated by commas);
10. type of the pre-question – pregradual/postgradual (dropdown box);
11. Importance 1–5 (probability of system choosing this question in random choice, where 3 is normal, 1, 2 should be used for rather rare and not crucial knowledge, 4 & 5 for essential facts);
12. Categorisation (module/study-program/subject/topic/subcategory).

If the prequestion has a language mutation the corresponding fields should be filled. The prequestion is the product of the student and could have arbitrary number of answers. These also could be as a text or media including its language mutations. The limit of answers per question is currently set to 12 but could be changed. The system recognizes also different roles of users. The roles are:

1. Superuser (absolute rights in the system, his right can't be restricted);
2. Administrator (nearly all rights in the system, his rights could be restricted);
3. No role user (guest – has no rights);
4. Teacher (rights of questions and tests management);
5. Student – proposer (could run the tests, propose pre-questions);
6. Student (could run the tests);
7. Official tester (could run the official tests).

The basic workflow in the system is following:

1. Creating the pre-question;
2. Creating/Accepting the question;
3. Official testing;
4. Non-official testing;
5. System management.

Creating a question

For example the process of creation a question looks like this. Imagine a medical student has an exam from internal medicine, surgery and radiology at the end of winter semester. Before he starts this semester he

knows he should choose (on-line) one of these subjects and that he will be required to make for example 20 questions from this subject. Either way he will study this subject during this semester very intensively. In the Opus Sapientiae there is a section for task administration – where students choose and teachers distribute ranges of recommended literature to be processed. This means that student goes through the text and each particular fact captures in the question or one of the answers. After choosing his preference for a subject for example radiology (picture 1) the teacher is on the move. Teacher sees the list of students enrolled on his subject and distributes the page ranges from recommended literature for each student. He could do it on the fly or from time to time. He distributes the ranges as he wish or he could respect the preference of the student as there is a place for short message for student when he is enrolling to a subject. All that is necessary to remember for a teacher is that the range should be reasonable for desired amount of questions. Rather smaller than bigger while it is important to avoid text processed with skipped facts. The list of enrolled students could be filtered and organized as desired. For example only students for particular subject could be displayed. Teacher sees the list on the picture 2 with student official photos. The comment field is shared with both student and teacher and could be previously filled with student request for a particular topic and teacher could rewrite it with his own comment to student. After teacher fills the resource and the range to be processed (for example book XY pages 12–15 or PowerPoint XY slides 4–10) and optionally write any comment, all is done. This process usually does not take more than 5–10 seconds. By entering the data he accepts the student and becomes his tutor.

After student creates a prequestion it is available for teacher edits. Teacher could reject question with or without writing a reason or request to the proposing student or just do nothing. He could also accept

it directly without any changes or do any desired changes and accept it. After teacher's acceptance the prequestion changes to question with the teacher as a tutor of the question and student as proposer. The question could be elected for a test. The system's improving quality of its questions is very important and to support this, Opus Sapientiae allows comments, feedbacks, and discussion for each question in the system. Even more during testing the user can make notice about any question or answer by one click directly in the test. This alerts any suspected incorrectness, incoherency, typing error or duplicity that is immediately announced to author of that question. Also if the user has proper rights he could edit any feature of the question/answer on the fly during testing (for immediate correction).

Each question in the system has its own life. This means it has a log of every change made to the question since its birth. Recording who and what changed to the question. After a significant change the system also changes the tutor of the question to teacher who made the change.

Creating a test

Test can be created with a teacher. The non-official tests are meant to serve as a remote practise for students. The internet access is not crucial to keep the Opus Sapientiae working. The server allows access through LAN within the whole hospital, where the department of dentistry and maxillofacial surgery is situated. The non-official tests are example tests that are useful for students who wish to test their level of knowledge mostly from home. If student decides to "learn directly from tests" there are few principles that render this choice extremely ineffective. Even if there is a non-official test designed with the same or similar parameters like the official one, the questions used in the test and even the answers are random so the student cannot reliably learn by heart the answers. If he repeats the tests again and again, he gets random questions with random answers and after few repetitions

he gets the tests with more and more questions he already got through. If the test is set up to pick 20 questions out of 3 folders with totally 500 questions and each question as approximately 10 answers and 5 of them are also chosen randomly... there is no reasonable way to learn from the tests. There is another principle that learning from the test makes ineffective. The huge ballast of basic facts the student already knows hinder the student in progress – in learning the new facts. Another important principle is that these new fact could student absorb from the test without any context. The retention of such information without understanding is very poor and obviously the advantage is on the side of students who study directly from books or other sources that support understanding and context. The coffin nail in demotivation of students avoiding the context and understanding of the facts is that most of the answers are or should be formulated in a way that concerns negative of the fact. Here is the example:

The question “When the patient collapses after local anaesthesia:” could have answers be like this:

1. we administer vitamin B and C;
2. we administer estrogens with noradrenalin;
3. we administer oxytocine;
4. we administer epinephrine with testosterone;
5. we must disinfect oral cavity with hydrogen peroxide.

All answers are wrong. If the question would be more sophisticated the tester needs to have a proper knowledge to identify the wrong answers. It is very hard and frustrating to memorize negative invaluable information. To learn by heart 10 things you would not do in some situation versus 1 procedure you should do. The number of correct answers is of course up to the creators of the question.

On the picture 3, there is a list of non-official tests created in the system. The flag represents language of the test. There is

information about number of questions and answers. When creating a test (picture 4), teacher could define over 20 parameters of the test. Here are just the most important of them:

1. Name of the test and its specification + their language mutations.
2. Optionally the targeted study year and study program.
3. Time of test availability (time & date).
4. The way of testing (by one question or all together).
5. Number of questions.
6. Number of answers in the test.
7. Time for testing (this is optional, if teacher decides for on-line testing, rather than to print out the test for paper versions).
8. Random order of questions or answers.
9. Preferred keywords – system with higher probability elects the questions with the preferred keyword (optional).
10. Proffered authors of the questions – the same like above.
11. Language of the test.
12. Allowing flash/sound/video (must be disabled for “paper testing”).
13. Difficulty index (explained later in the text).
14. Showing answers (immediately after each answered question OR after finishing the whole test OR don’t show).
15. Evaluate test yes/no.
16. % criteria for passing the test (optional).
17. Method of test evaluation (standard, double, university, whole answers or inverse).
 - a. standard = one answer – one point;
 - b. double = each answer – two points;
 - c. university = the interval $<0, 100>$ points is projected to $<\text{minus } 50\text{points}, \text{plus } 50\text{points}>$ the same for percents;
 - d. whole answers = maximum points is the number of questions;
 - e. inverse = it is more like “sudden death” where system counts your wrong answers – you could set limit for wrong answers.

18. Record high score from this test to “hall of fame”? yes / no.
19. Choosing folders/categories from which the questions are randomly picked up.

Here it is very important to emphasize that one of the first motives for creating the Opus Sapientiae was fact that medical students were not often repeating their knowledge. And as everybody knows “Repetitio Est Mater Studiorum” the project pushes to repetition of pre-requisite subjects. During creating the test is encourages you, in fact it requests, to choose 30% of the total test questions from other subjects which you find concerning the main subject of the test. This rule could be bypassed. It often happened that students after passing for example the biochemistry exam stated that they doubt that they will ever use 90% of their biochemistry knowledge later in their medical studies. This is the main reason of “studying for the exam” habit. And if students are aware of this rule they would benefit from their studies and will appreciate to learn with long term retention aspects. Otherwise they will not see the point to keep the Krebs cycle in their heads for longer time.

Choosing the folders (module, study-program, subject, topic and subtopic) allows structuralizing your test very precisely. The Opus Sapientiae has an internal structure of folders. The “module” represents a friendly medical faculty / university cooperating in the project, study-program is for example dentistry or general medicine, subject is mostly understood as official subject in curriculum like radiology, restorative dentistry or orthodontics. Topic within a subject could be for example “caries” in restorative dentistry. You could create a question even without moving it to a particular folder and do it later. The subtopic is optional and helps you to make a better order within your topic or later to pick up from smaller sets of questions. Reordering of questions is easy. The questions are supposed NOT to repeat. So when creating a test for example from orthodontics you could take:

5% from MODULE (OUSA-St.Elisabeth oncology institute) /// STUDY-PROGRAM (general medicine) /// SUBJECT (radiology)

15% from MODULE (LFMU- Masaryk University) /// STUDY-PROGRAM (general medicine) /// SUBJECT (histology) /// TOPIC (embryology) /// SUBTOPIC (teeth)

10% from MODULE (LFUK-Comenius University) /// STUDY-PROGRAM (dentistry) /// SUBJECT (paediatric dentistry) /// TOPIC (teeth eruption) ///

Here we have filled the 30% for repetition from 3 different universities (we like their questions, we made our language mutation for them, they use the literature we also recommend etc..)

65% from MODULE (LFUK- Comenius University) /// STUDY-PROGRAM (dentistry) /// SUBJECT (orthodontics)

5% from MODULE (JLFUK- Comenius University-Martin) /// STUDY-PROGRAM (general medicine) /// SUBJECT (surgery) /// TOPIC (maxillofacial surgery) /// SUBTOPIC (orthognatic surgery)

This puzzle makes together 100% where 30% is repetition, it is not necessary to use other university modules, but it is probable the use of questions from cooperating medical faculties will grow in an effort to have as many as possible questions in the pool.

System indexes

To improve the system over time by analysis of student behaviour in the system, many background processes are set up. One of the most important quality sentinel flags is the index of difficulty. The teacher might want to generate a difficult test or opposite. To do so, it must be possible to identify more difficult questions/answers. Only objective way is to make statistics for each answer. Index of difficulty is of course evaluated only from official testing to avoid intentional mistakes made by students in non-official tests to make easy answers look difficult. Index of difficulty is the ratio of correctly answered questions to number of totally answered

The figure shows three examples of test forms from 'Opus Sapientiae'. The top two are identical and represent a 'paper test /PDF'. Each form includes a header with the logo, a section for student information (Meno, Smer, ISIC, Ročník), a version number (verze: 1), and a table for question selection. Below this is a list of five multiple-choice questions related to general diseases of the mouth mucosa, dental focal infections, frenulum labii, mandibular structures, and tooth development disorders. The bottom example is a 'correcting table' (answer sheet) with two versions (verze 1 and 2). It contains a table for marking answers (A, B, C) for each question, with some cells already filled in.

Opus Sapientiae

Meno: Popis:
Smer: Ročník:
ISIC:
verze: 1

1. A B C	2. A B C	3. A B C	4. A B C
5. A B C			

- Manifestations of general diseases on mouth mucosa:
 - hypovitaminosis B1 causes dry lip
 - abnormally low level of iron causes scurbut
 - avitaminosis of vitamin C causes scurbut
- Dental focal infection:
 - etiological agent is metabolite in infective focus in mouth
 - the cause is chronic inflammation focus in teeth area
 - etiological agent is bacteria in infective focus in mouth
- The most common surgical method in frenulum labii is?
 - Frenulotomy
 - Apical moved flap
 - Frenulectomy
- The most equalised structure in mandibulae is?
 - processus coronoideus
 - linea obliqua
 - spina nasalis inferior
- What is true in context with teeth development disorders
 - Damage of bud during histodifferentiation has as consequence damage of enamel
 - Damage of bud during morphodifferentiation has as consequence abnormal toothsize
 - Damage of bud during morphodifferentiation has as consequence abnormal toothnumber

Vytlačil: PRUK, Andrej Thurian, 8.10.2009 10:31:36 1 / 1

Opus Sapientiae

verze: 1

1. A C	2. A B C	3. A	4.
5. B			

verze: 2

1. A C	2. B	3. A B C	4. C
5.			

Figure 5. Example of paper test /PDF, answer sheet at the top, correcting table at the end.

questions. The smaller it is – more difficult is that particular answer. When creating the test this parameter could be entered. From other background evaluations alerting on incorrect or unclear questions and answers, is one another index necessary to mention. It is the “age of the test”. This is the average year of the literature used as reference for the questions. This means, the higher the year is – the test is more up to date. This makes a pressure on authors and proposers to look for as fresh resources as possible. Even the “old truths” in the questions referring to on old research could be updated with a new publications dealing with that particular fact. This could be done only with updating the literature reference in older questions. The test with the age 1980 would be for example a test with 4 questions refer-

ring to articles from 1950, 2010, 1978 and 1982.

Testing

There are two main concepts how to test with the Opus Sapientiae. First is “paper testing” and the second “on-line testing”. The paper testing allows generating test from official test in desired amount and type. By type are understood various groups/mutations of the same test. For example you could generate 10 tests for your 10 students however if they sit too close to each other so you prefer to have different test versions. The difference of the test you could be defined as:

- Everybody has a different test (different questions and different answers).
- Everybody has the same questions but different answers.

3. Everybody has the same questions and the same answers but in random order that makes the cheating nearly impossible.

Of course you could print 1,000 copies of the same test if you wish. All paths above are done through direct PDF export from the system. The PDFs could be stored or archived, this works also for the PDF exported from on-line student testing. If you dot trust archiving the student test result on-line you could print them out and store in the safe. To generate the same test with random order of the questions and answers

is one of the most popular while the students cannot complain somebody has more difficult test. The results are then truly comparable.

The most interesting feature in paper testing is the “correcting template/table” which is printed as last page after the test and is a very useful tool for the teacher. It shows a table with correct answers that could be used by a teacher correcting the test after students. This will significantly speed up the way of correcting the tests and make it more comfortable for the teacher. On the picture 5 is the example of two tests with five questions each. The questions are the same but

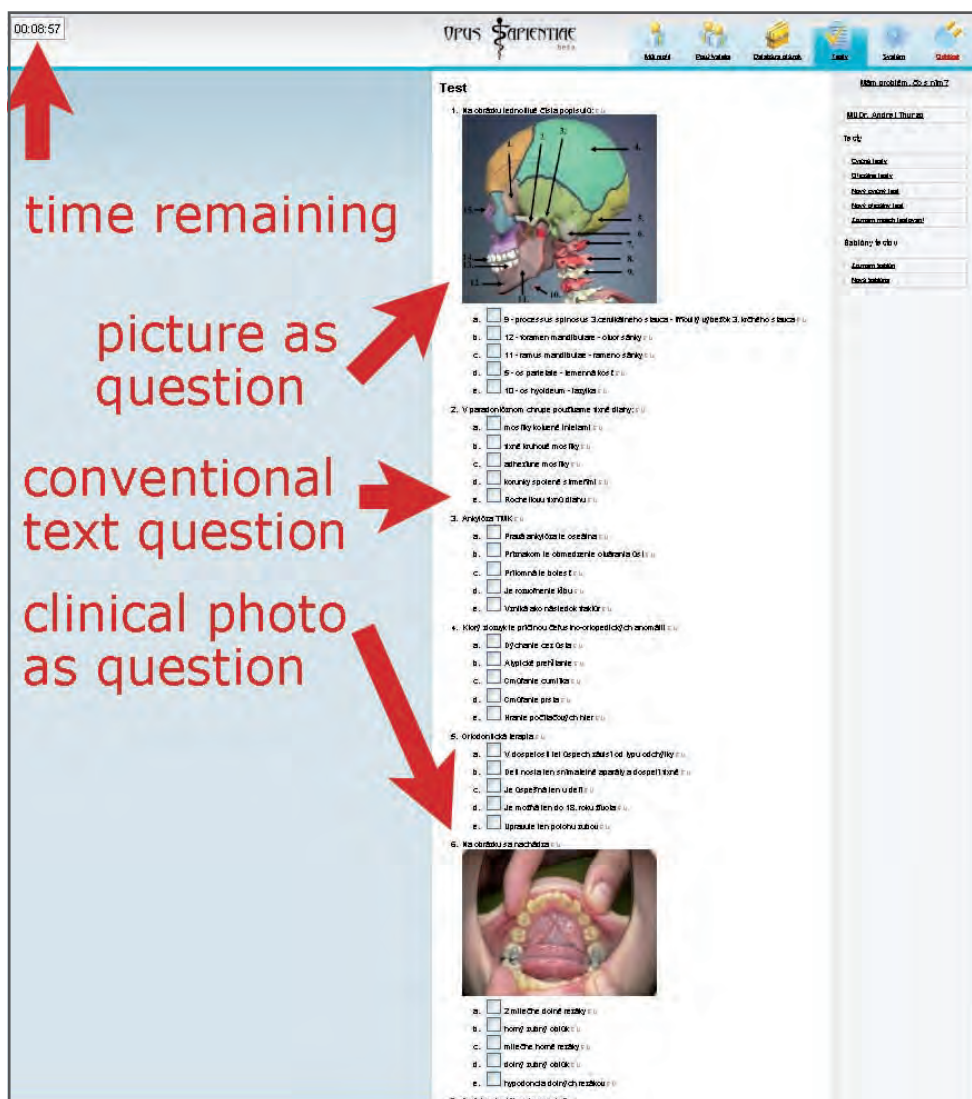


Figure 6. On-line testing, example of timed multimedia 5-answer-test showed at once.

not the answers. At the beginning of each test there is the header which the student is supposed to fill. The answer sheet after this header is the most important. It is always on the first page of the test. If the test has more pages it would be chaotic and difficult for teacher to search for answers. All the teacher needs to do now is to compare his correcting table with the answer sheet of the first page (they look the same).

On-line testing (picture 6) is more fun with immediate evaluation, ready to be archived as PDF, stored automatically; allowing use of multimedia and many other advantages. Only requirement for successful on-line testing is a set of desktops with web/LAN access. The ideal change the system induces in students learning is:

1. Student studies from books, lectures, on-line sources according to defined topic.
2. Student uses the Opus Sapiientiæ only for continuous checking the level of his knowledge. Especially for checking his retention knowledge of previous subjects.
3. The Opus Sapiientiæ is used by teacher as complementary tool and saves time in verification of basic facts that student should know. And so oral examination could be used only to check student skill to think, combine and interlink acquired facts.
4. Opus Sapiientiæ serves as filter for “exam gamblers” trying to slip through exam with minimal knowledge, only with luck – if met with particular topic he knows.

Technical background

Former developing location was at www.elcoms.sk/demo/kega/sk/.

Current redirections to 172.22.3.22 are www.sapiienti.ae and www.opus.sapiienti.ae

Logo of the project is:



Since February 2010 the system has been moved to an autonomous server to improve the security and performance. Opus Sapiientiæ does not require its own server. The current server parameters are:

Processor: x3550 M2, Xeon 4C E5520 2.26GHz/1066MHz/8MB L3, RAM: 8GB RAM PC3-10600 CL9 ECC DDR3 1333MHz Chipkill LP RDIMM, Hard-drive: 3x IBM 73 GB, 6Gbps SAS HDD + ServeRAID-MR10i SAS/SATA

Project in numbers

1. 1. 2010 Opus Sapiientiæ contained 391 questions in total. All were created during development phase, directly by doctors/teachers with more than 3,100 answers in the subject “dentistry” in general medicine study program (English and Slovak mutation). Students have been already officially tested by paper-testing in 2009. There are 2,464 pre-questions waiting for acceptance with more than 20,000 answers. This is a result of 3-month crowdsourcing. Further development of the project will aim to successful launch on the new server, dealing with minor bugs and creation of further language mutations for questions and system menus. Improve the cooperation within Mefanet network, especially to deal with identification issue that is currently done with Comenius University student database. The goal is to adopt a wider and secure student identification system and support friendly medical faculties with this useful tool.

Acknowledgement

Creation of the system and supporting hardware was partially funded by grants: KEGA #3/6055/08. AV#4/2027/08, VEGA #1/0460/09 and Ministry of health #2007/37-UK-19. For DEMO access please write to thurzo@bsm.sk

References

1. Thurzo A. et al., Projekt Opus Sapientiæ. [Online]. Available: www.opus.sapienti.ae
2. Mesko D, DIGITAL M-EDUCATION ERA, Mefanet report 02, page 19
3. Dušek L, Schwarz D, Stipek S, Stuka C, Project MEFANET– a New Kind of Collaborative Space for Electronic Support of Medical and HealthCare Education, Mefanet report 02, page 25
4. The Nielsen Company, Time Spent on Facebook up 700%, but MySpace Still Tops for Video. [Online]. Available: http://blog.nielsen.com/nielsenwire/online_mobile/time-spent-on-facebook-up-700-but-myspace-still-tops-for-video/

12

LABTUTOR AND LMS MOODLE IN PHYSIOLOGY LESSONS

Bužga M.¹, Závacká I.², Orzelová L.³

¹ *University of Ostrava, Dept. of physiology and pathophysiology*

² *University of Ostrava, Dept. of Examination Methods and Medical Biology*

³ *University of Ostrava, Centre for Information Technology, University of Ostrava*

Abstract

The introduction of Biology is one of the most distinctive aspects of a present medicine and all the disciplines directly connected with medicine itself. This fact must necessarily affect the study run of all the undergraduates working in medical professions and therefore play an Essentials role in the curriculum of Physiology. The practical education in physiology and pathophysiology requires that all the non medical bachelor or master graduates could get high – quality practical as well as theoretical knowledge they could use in their future professions. Concerning these facts the Dept. of physiology and pathophysiology uses LabTutor together with The Moodle System. All the single lab tasks are administered by the only software of LabTutor. The system covers all the physiology topics like cardiovascular system, digestive system and complicated neurophysiological tasks. The advantage of the system is a long time period work with the same lab appliances during the run of lessons. The LabTutor is able to navigate students in their working procedures and simulates physiological processes of human beings and at the same time does all the measurements and processes the information. The result of the work is the final lab report. LMS Moodle enables a sophisticated administration of the whole learning process during the lessons of physiology. During the run of the two-term course all the students are divided into small working groups so that they could work on practical tasks in pairs and therefore have the maximum active participation in lessons.

In Moodle all the study materials and particular assignments can be handled by students before the lessons start. The final lab report, which is produced by LabTutor, is finally entered by students to the Moodle, where every report is evaluated with a different number of credits (points) and commented by the tutor.

The interactive e-learning is a suitable form of education for the present students. E-learning systems can be used anywhere and at any time. While preparing or processing the final reports from practical trainings (lessons) the student can use all the electronic materials saved in the intranet repository. The great advantage of the process is that instead of the paper records we use an electronical form of reporting and so we have cut down on administrative work which used to be connected with the preparations of every practical physiology lesson.

Keywords

learning module system, Moodle, Lab Tutor, Interactive teaching

Introduction

The introduction of Biology is one of the most distinctive aspects of a present medicine and all the disciplines directly connected with medicine itself. IT spreads

various information concerning biological disciplines as well as the technical advancements, which improve the diagnostics and the therapy up to a cellular or even subcellular level. These facts must necessarily affect

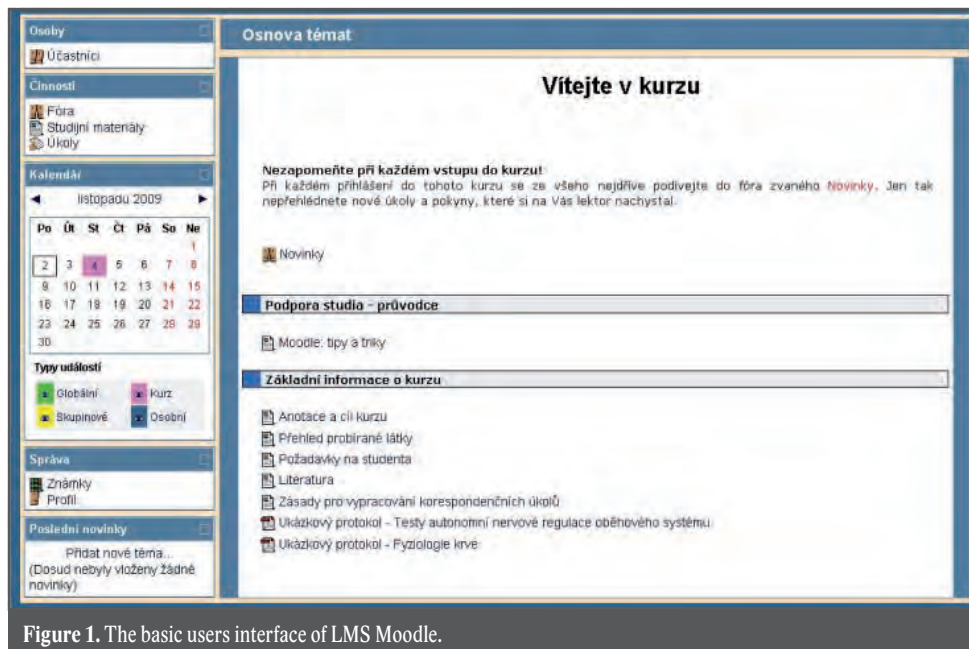


Figure 1. The basic users interface of LMS Moodle.

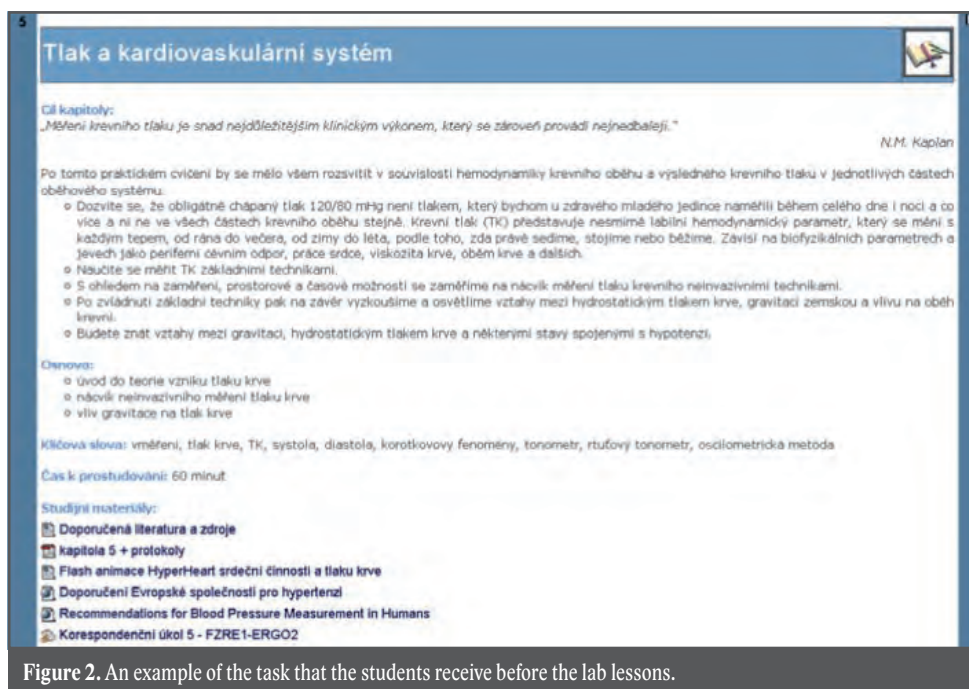


Figure 2. An example of the task that the students receive before the lab lessons.

the study run of all the undergraduates preparing to work like doctors or in various non medical professions and therefore play an Essential role in the curriculum of Physiology. It is understandable that such a process must also have an important effect on the coming changes like subject matter or even education technologies. The technologies are aimed at education strategies, an

results evaluation and finally the choice of the appropriate learning Instruments which maximize the student's activity during lessons and thus enlarges the possibility of a future job finding.

Our present experience shows that information technologies (information appliances) usage in physiology lessons can be a strong point of motivation for every student and

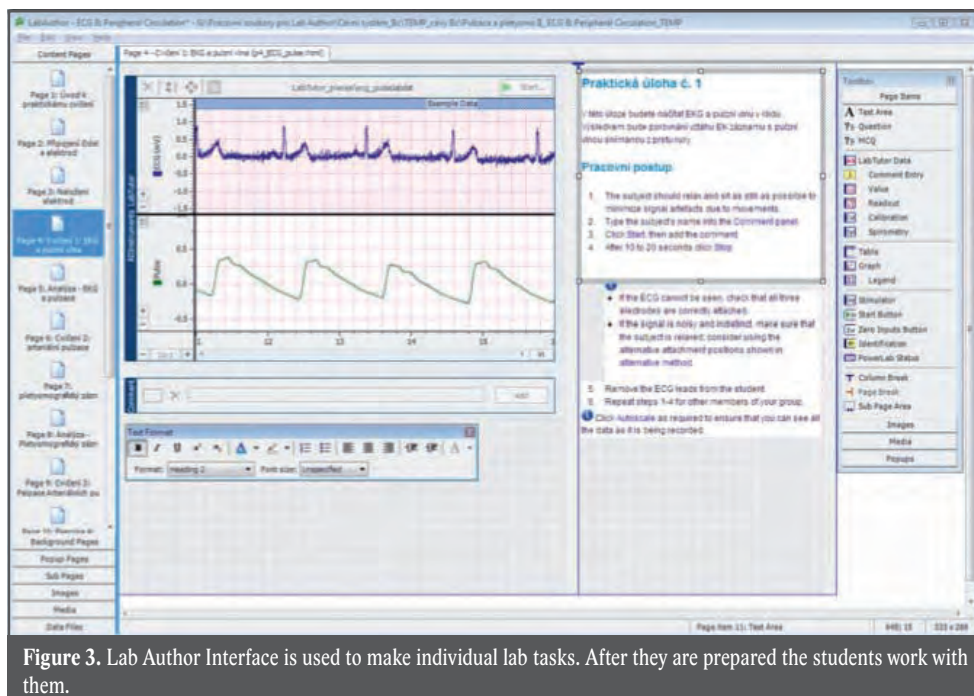


Figure 3. Lab Author Interface is used to make individual lab tasks. After they are prepared the students work with them.

therefore enlarges their activity. This kind of education also helps students to get across a passive kind of learning to an active one, where they are able to solve practical problems.

The problem solving

According to a reason written above our Department uses Tutor and Moodle together. LMS Moodle enables a sophisticated administration of the whole learning process during all the physiology lessons taught at the Faculty of Health Studies (figure 1). During the run of the two-term course all the students are divided into small working groups so that they could work on a practical task in pairs and therefore have the maximum active participation in lessons.

In Moodle all the study materials and particular assignments can be handled by students before the lessons start. Everything can be found on one place (figure 2).

The system Lab Tutor is used directly for lab lessons, where the students solve practical physiology problems. This system is very easy to use. Everything from the experiment protocol, through to data acquisition,

analysis and reporting is displayed within the familiar Internet Explorer browser. Internet connection is not required. The whole system cooperates with a hardware known as Power Lab run by the Company of AD Instruments. The single lab exercises covering all the physiology topics like cardiovascular system, digestive system and complicated neurophysiological tasks are processed in LabTutor. The advantage of the system is a long time period work with the same lab appliances during the run of lessons

The system of Lab Tutor not only guides students through the installed sets of experiments. Its interactive features enhance the learning experience by reducing the complexity of data acquisition and increasing the significance of the relationship between the recorded data, its analysis and the questions posed in the report section. Pre-experiment preparation is virtually eliminated by including all the information and required tools within the LabTutor experiments. No written notes or settings files are required. Each experiment is ready to go. Acquired data, analysis and written reports are auto-

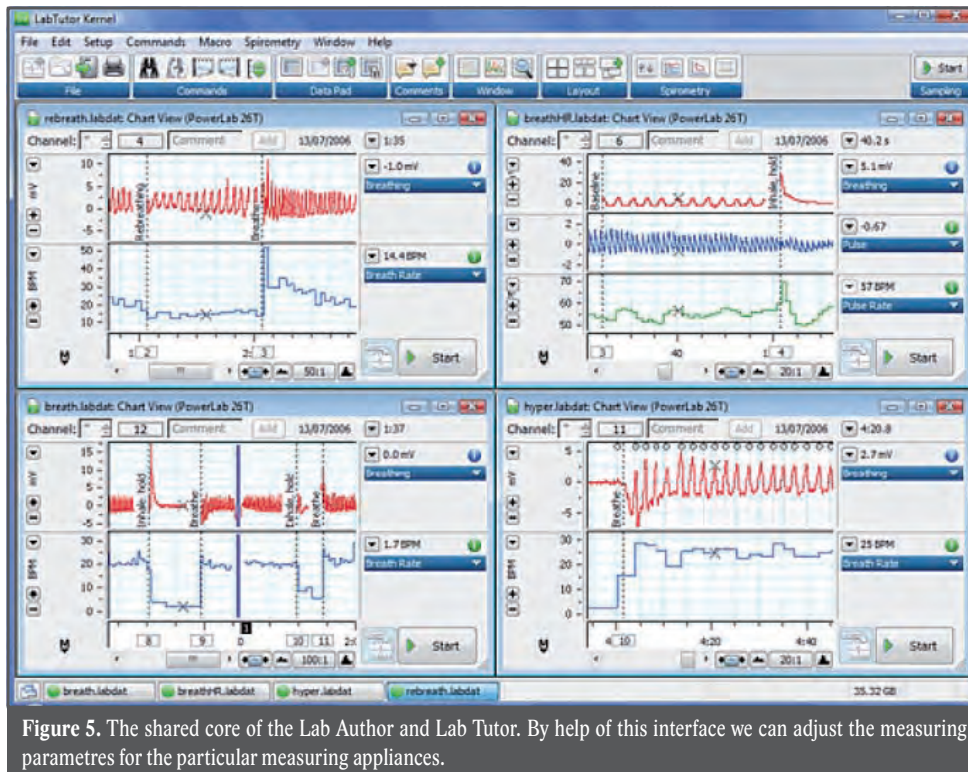


Figure 5. The shared core of the Lab Author and Lab Tutor. By help of this interface we can adjust the measuring parametres for the particular measuring appliances.

matically and conveniently saved within one file for easy review or printing.

The Lab Tutor cannot be edited by the teacher. To be able to edit you have to use the software tool Lab Author. LabAuthor software provides educators with an easy-to-use tool for editing and writing LabTutor experiments. LabAuthor users can edit any of the preconfigured physiology, pharmacology or biology LabTutor experiments, or create their own experiments using the student-friendly LabTutor interface and step-by-step experiment structure (figure 3). Easy-to-Use Authoring and Editing Tools LabAuthor educators do not have to learn any programming or html code. The software has a straightforward graphical user interface. We simply click, hold and drag new objects, text and graphics into the experiment pages. Users can also edit the pages of existing LabTutor experiments quickly and easily. The LabAuthor Toolbox provides all the tools what we need. Formatting toolbars and menus appear once we have selected a specific object. We can use the LabTutor Kernel to set up data acquisi-

tion channels with the correct filtering and display settings for your signal and experiment (figure 4).

The result of the practical physiology education is the final lab report. The lab report is generated by the Lab Tutor after the exercises from the charter have been done. The students have the chance to correct and comment their work in the lab or at home after the lesson. The final lab report, which is produced by LabTutor, is finally entered by students to the Moodle, where every report is evaluated with a different number of credits (points) and commented by the tutor.

The lab reports must be handed within a limited period of time agreed before. Each group of students has own term of hand over. The students then must work and study regularly. The students take Moodle as a virtual class in which they can communicate with the tutor as well as other co-workers. In these cases the discussing forum is used. In case of any uncertainties the students can address the tutor with a question that he needs to answer. Also

co-workers can help or advice. This is good for collective thinking and mainly for team work and cooperation.

Concusion

The interactive e-learning is a suitable form of education for the present students. E-learning systems can be used anywhere and at any time. While preparing or

processing the final reports from practical trainings (lessons) the student can use all the electronic materials saved in the intranet repository. The great advantage of the process is that instead of the paper records we use an electronical form of reporting and so we have cut down on administrative work which used to be connected with the preparations of every practical physiology.

E-TESTING IN HEMATOONCOLOGY

Komenda M.¹, Adam Z.²

¹ *Institute of Biostatistics and Analyses MU, Brno*

² *Department of Internal Hematooncology, Faculty of Medicine MU, Brno*

Abstract

Another step forward in the modernization of education at the Faculty of Medicine MU is using electronic tests for the final evaluation of students after the internships programme. Continuous training knowledge validation and final testing with the aid of special application called ROPOT (Revision, Opinion Poll and Testing), that are available in e-learning agenda of Information System MU, are becoming more popular not only among teachers, but especially for the students themselves. Every two weeks during semester we have executed electronic tests in the computer classrooms of IBA for students who have just completed an internship programme.

Keywords

hematooncology, testing, e-learning

General information

Under the leadership of prof. Zdeněk Adam, MD, PhD, was created the database of questions, which serves as a source for generating completely random and unique pc-based tests. After successful login, the Masaryk university Information System

(IS MU) automatically produces unique multiple-choice test, which is consisting of twenty questions. Maximum allowed time for answering is thirty minutes.

Due to the considerable possibilities of IS MU, the question of safety finds clear and easy answer. The combination of date



Figure 1. Supervision of students.



Figure 2. Sample of available column color.

restricting access to the ROPOT, constraints for the IP addresses of computers in the classroom and live supervision of technician, ensuring full control over all students and rule out any attempt at fraud. It is interesting to show color bar at the left of the screen when you activate a test. If the bar disappears from the screen, it indicates that the student has left the testing agenda in IS MU, which is strictly prohibited. As you can see in figure1, the selection of appropriate place in the classroom causes easily computer supervisory.

Safety settings

All safety parameters are setting up in ROPOT description. There are a lot of pre-filled items related with selected mode (for example: exercises, PC-based test, PC-based test demo, scannable test, etc.). We used PC-based test for submitting computer-based tests to students. Most important are the following settings:

- Identification column

Provided you plan to have your students answer their questions on computers in a computer room and you want to be able to visually check if they only work with the windows loaded with answer. This will add to the answer sheets a column of the selected color.
- Date restriction

Teacher can fill the period, stick to the required format (16 02 2010 09 00 means 16th February 2010, nine o'clock), during which the application can be worked

with. If no information is provided, the students will be allowed to work with the ROPOT application any time they decide to do so.

- IP address restriction

Provided this ROPOT application is intended to serve the purpose of a written examination taking place in a certain location (e.g. a computer room), you can use this section to specify the computers from which your students should be allowed to access it. This helps you to prevent the situation in which a student is having answer form filled in by someone else who is using the password belonging to the former and working with the form from another location. The IP addresses (and/or their range) should be entered in the required format: from 147.251.51.100 to 147.251.52.200. Every time a ROPOT application is accessed, the Information System saves the IP address of the computer from which this is done. Therefore, it is always possible to check the IP address records for unauthorized access even after the examination proper.
- Rights of access

Provided this application is intended to serve the purpose of an examination, you should limit the access to it to the students who have reserved a slot on a certain examination date.

Statistics view

We have verified using prospective randomized comparative study that this method works excellently (data was collected in autumn 2009). In this study, our first group of students knew that they will be tested after the end of the course, but results of

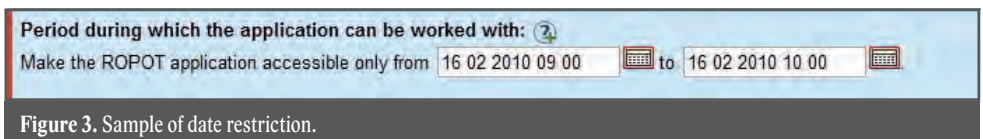


Figure 3. Sample of date restriction.

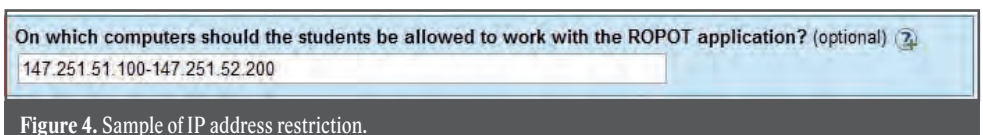


Figure 4. Sample of IP address restriction.

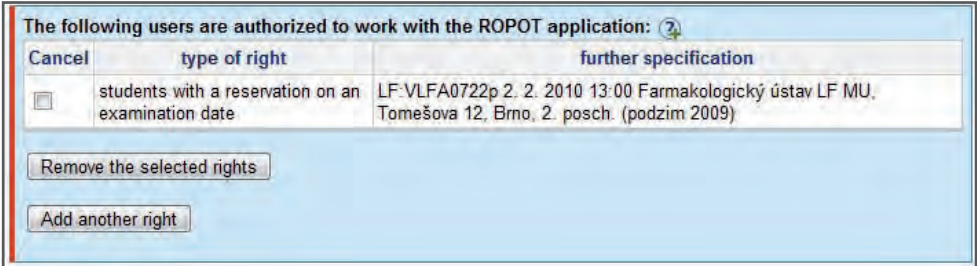


Figure 5. Rights of access sample.

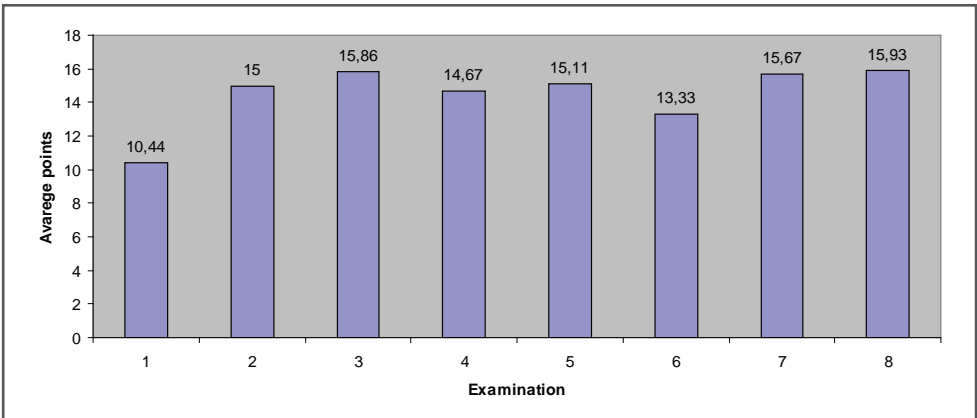


Figure 6. Statistic of examination terms.

tests won't be a condition for getting credits. The average number of well-answered questions in first group was 10.44 points of 20. Students from another groups already knew that the credits will be granted only when they will passed the exam (to get at least fifty percent from 20 possible points). The average number of correctly answered questions was logically growing up. As you can see in figure 6, we posted eight exami-

nation terms. The total number of enrolled students was 130.

All teachers felt students carefully follow instruction, ask and discuss. Multiple choice tests appear to be the best solution how to evaluate students after the internships programme. Increasing the availability of computer classrooms would allow electronic evaluation of students before the oral examination after finish whole field.

References

1. Information System of Masaryk University. [Online]. Available: <http://is.muni.cz/>

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“NURSING IN ACTION” – THORNY WAY TO THE GOAL

Kašpárková J.

Department of Nursing, Faculty of Medicine in Pilsen, Charles University in Prague

Abstract

In this paper, I would like to carry out a transformation of the reader, through the e-Learning courses at our department. They offer a brief initial appearance rate (on 1 demo), then the necessary steps to identify and remedy deficiencies and, finally, a new form of courses.

Keywords

courses, evaluation, teaching parameters

Introduction

Experience with e-learning education in Bachelor of Nursing programs are presented at 1th Conference Mefanet in 2007^[2]. Since then we have exhausted the relatively large number of courses, but no prior teaching preparation. Rates do not reach the required teaching parameters.

The project DIV 2009 I focused on the qualitative transformation of our courses, which began its evaluation through completion copyright course tutor and gradual adjustment of rates under the rules of teaching.

Original Courses

Since 2005 we have created 7 courses with 17 thematic units. The resulting courses contain a total of 58 teaching materials in the form of lectures with full control issues, supporting learning materials, individual tasks, small (control) and large (compensatory) tests.

With the experience gained, we gradually gave courses at least a visual appearance (editorial, course objectives, content, keywords, theme goals, color coding topics). However, quantitatively rich set of materials

Figure 1. The form of the original theory of nursing course (only a part).

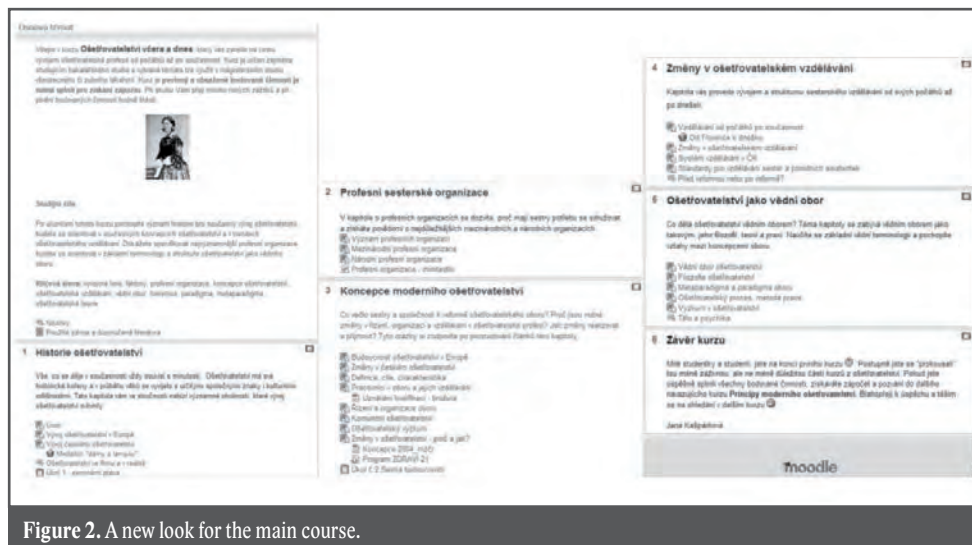


Figure 2. A new look for the main course.

was, and largely still is, didactically "imperfect". Except for minor exceptions lacking type, content and structural diversity of courses. Besides images, tables and hyper-text links do not contain any other multimedia elements (animation, video) and with little use of communication channels (forums, chat). Study materials were comprehensive and the reader often have a lot of "scroll" than it studied.

The process of transformation

The professional meetings with experts in the distance education, we sensed the need to change the current situation and provide study materials such a form that is didactically sound and fun for students. Qualitative transformation of courses has become our primary objective for the price of consciousness that we expect long-term and intensive process.

The whole process implemented in several steps:

- 1st Evaluation of existing courses by teaching criteria
- 2nd Passing distance course "Copying and tutor work in e-learning"
- 3rd Setting realistic targets for personal transformation
- 4th Makes changes

Colleagues in the workplace OVAVT (Department of teaching and application of computer technology) got the task of evaluating all the materials have been generated for the distance education. According to the content and features put into the corresponding categories of courses (electronic support, blended-learning course, fully distance courses, courses designed to test students) and according to clearly defined criteria objectively evaluate its quality [3]. All makers were introduced of the results of the evaluation as well as the correcting.

Another necessary step before the actual transformation of courses to passing distance course "Copyright and tutor work in e-learning" PaeDr. Jany Vejvoda. This course was mandatory for all authors. In addition to acquiring basic educational skills, this course was more positive – the opportunity to experience fully distance course in the student role and the individual tasks to consult or modify previously created courses.

Didactic foundations and results of evaluation are the starting line to change materials. Everything can not be edited at once, so we had to decide and choose a course that is at this moment to adjust priorities. We had to set clear and realistic goals, so how we are able to adjust to the end of the calendar year.

Courses in the "new coat"

Our courses are created from the outset and built by following the course of study. Why I started working from the first course. Courses have begun to acquire a new form of teaching necessary for compliance with rules.

So far, the largest and most important transformation undergone the initial course "Theory of Nursing". That was very extensive, with large issues and small interactions. The course was divided into two new courses ("Nursing Yesterday and Today" and "The Principles of Modern Nursing"), which are thematically different but each of the successive. The topics were distributed to study cells, which are smaller units of study which do not need to scroll too. The

topics are discussion forums, individual tasks, small and large tests. See Figure 2.

Of materials, we also put more hypertext links that enrich the information in the articles. Links are in various forms – articles in encyclopedias, Web sites and videos from the YouTube portal. At the stage of development are simple animated diagrams and images that we create in collaboration with colleagues from OVAVT.

Conclusion

Path of quality and empowered the Study material is long, arduous and especially needed. We are aware that much remains to work on adjustments to create new originating materials.

References

1. J. Kašpárková, E-learning in bachelor's study of nursing at Faculty of Medicine in Pilsen, In electronic proceeding of 5th Conference "Alternative methods of teaching in 2007". Prague, Faculty of Science, Charles University, Prague, 2007.
2. Kašpárková J., "Nursing in action, our experience with e-learning in bachelor's study of nursing at the Faculty of Medicine in Pilsen," In Proceedings of electronic lectures MEFANET 2007. Brno, 2007, ISBN 978-80-7392-007-4.
3. Vejvodová J., Navrátil M., Míka P. "Evaluation criteria for the evaluation of electronic courses (2009, May). [Online]. Available at [www. http://mefanet.lfp.cuni.cz/clanky.php?aid=3](http://mefanet.lfp.cuni.cz/clanky.php?aid=3)

ETHICAL ISSUES IN BIOMEDICAL RESEARCH IN EUROPE

Kinkorová J.

Technology Centre, Academy of Science of the Czech Republic

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Abstract

Biomedical research not only in Europe but all over the world operates with huge amount of data uniquely determining persons/patients. There are not unified ethical rules for biomedical research neither at national levels nor at the European level. Main problem to solve now is to prepare European ethical rules for informed consent, protection of human rights and dignity, and human data. Another main issue in biomedical research that currently undergoes great changes is the research with the use of animals. The aim of the article is to contribute the awareness of importance of handling of and using information to be subject to ethical review at European level. The article has to highlight a number of questions to be answered in process of understanding ethical rules.

Keywords

ethical issues, European biomedical research

History

The main point in history of ethical rules was the end of the Second World War and the outlawing gross abuse of human beings. The first step in the process of formulation ethical rules was the Nuremberg code (1947) as a set of research ethics principles. Nuremberg code was based on six points defining legitimate medical research presented by Dr. Leo Alexander, an American psychiatrist and neurologist of Austria-Jewish origin. Then the trial verdict adopted additional four principles which altogether constituted the Nuremberg code ^[1]. The main document regarding ethical issues was developed by World Medical Association (WMA) in 1964, Declaration of Helsinki ^[2] as a statement of ethical principles to provide guidance in medical research involving human beings. During the last decade, the time of building the “European Research Area” and forming “European biomedical research area” new questions were asked to be answered and new problems appeared to be solved ^[3].

Current key issues regarding ethical issues are: informed consent, data protection and

privacy, research on animals, that are the aim of the present article. Special attention in the European research area is devoted to the research in developing countries, research on human embryonic stem cells (hESC), and dual use risks.

Informed consent

The informed consent process is designed to inform the subject of the risk, rights, and benefits of participation in a clinical research trial [4]. Informed consent can be obtained only from persons able to freely understand and question should give consent. Vulnerable persons like children, prisoners, pregnant women, mentally-deficient persons, etc. must be excluded. The information should be in the mother tongue of the person and that is fully understandable. The informed consent should state that the study involves research, explain the purpose and expected duration of the study, and describe all procedures that the person will undergo during the study. The informed consent should describe any possible risk or discomfort, and also any benefits which can be expected. The informed consent should

include the statement describing the extent to which confidentiality of data identifying the person will be maintained, and the person-specialist, psychologist to whom the person can ask any question about the research, human rights etc. And finally the informed consent should include the statement that participation is voluntary and the person can refuse to continue any time without any penalisation and loss of benefits.

The informed consent is to be obtained in case of involving children or persons not able to give consent, when the research involves human beings, in case of use human genetic material or biological samples and in case of the research involving human data^[4]. Because of many other questions regarding informed consent, two other recent publications are mentioned: Wakeel et. al^[6], Delany^[7, 8].

The informed consent is dealt with in Czech legislation, in particular in Act No. 387/2007 Coll, as amended. Interpretation of the term informed consent is contained in “Resort Program for Research and Development of Ministry of Health III. (hereinafter only RPRD III.)”.

Data protection and privacy

Health information, criminal justice, genetic information and others are affected by data privacy issues. The objective in data privacy is to share data and at the same time protect personal identity in the process of personal data obtaining, holding and disclosing. The European Directive 95/45/EC [8] on the protection of individuals with regard to the processing of personal data and on free movement of such data contains eight enforceable principles: fairly and lawfully processed, processed for limited purposes, adequate, relevant and not extensive, accurate, not kept longer than is necessary, processed in accordance with data subject's rights, secure and not transferred to countries without adequate data protection.

If the data are saved for further research they are either anonymized (impossible to link data with an identifiable person) or coded (to identify someone's data so that personal details can still be identified by specific requests and safeguards). Even if the coded and anonymised data are used adequate security must be demonstrated.

Research with the use of animals

Directive 86/609/EEC^[9] regulates the use of animals for experimental and other scientific purposes. The Directive aimed to reduce the numbers of animals used for experiments by requiring that an animal experiment should not be performed when an alternative method exists, and by encouraging the development and validation of alternative methods to replace animal methods. The “3 Rs” are guiding principles for the use of animals in research in many countries of the world: reduction – refers to methods that enable researches to obtain comparable levels of information from fewer animals, or to obtain more information from the same number of animals. Replacement – refers to the preferred use of non-animal methods over animal methods whenever it is possible to achieve the same scientific aim. Refinement – refers to methods that alleviate or minimise potential pain, suffering or distress, and enhance animal welfare for the animals still used. At the time the Directive 86/609/EE is being reviewed. Current status and new trends are actually presented at The National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs), established by the UK Government, is an independent scientific organisation, and the largest funder of 3Rs research in the UK^[10], or ECVAM (European Centre for the Validation of Alternative Methods)^[11].

References

1. The Nuremberg Code (1947) In: Mitscherlich A, Mielke F. Doctors of infamy: the story of the Nazi medical crimes. New York: Schuman, 1949: xxiii–xxv.
2. World Medical Association Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. Available from: <http://www.wma.net>
3. Directive 2001/20/EC of the European Parliament and of the Council of 4 April 2001 on the approximation of the laws, regulations and administrative provisions of the Member States relating to the implementation of good clinical practice in the conduct of clinical trials on medicinal products for human use. OJ L 121, 1.5.2001.
4. Smith-Tyler J., Informed Consent, Confidentiality and subject Rights in Clinical Trials. *Proc Am Thorac Soc* 4: 189–193, 2007.
5. Council of Europe – ETS n° 164 – Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine: Convention on Human Rights and Biomedicine, Oviedo, 4.IV.1997. Available from: <http://conventions.coe.int/treaty/EN/Treaties/Html/164.htm>
6. El-Wakeel H., Tailor G.J., Tate J.J.T., What do patients really want to know in an informed consent procedure? A questionnaire-based survey of patients in the Bath area, UK. *J Med Ethics*, 32: 612–616, 2006.
7. Delany C., Making a difference: incorporating theories of autonomy into models of informed consent. *J Med Ethics* 34:e3; doi:10.1136/jme.2007.023804, 2008.
8. Council Directive 95/46, art. 25, 1995 O.J.(L 281) (EC). Available from <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:EN:HTML>
9. Council Directive 86/609, 1986 O.J.(L358) (EC)
10. <http://www.nc3rs.org.uk/category.asp?catID=3>
11. <http://ecvam.jrc.it/>
12. Pauwels E., Ethics for Researchers: Facilitating research excellence in FP7. Brussels: EC 32 pp., 2007

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