EJBI 2011 ISSN 1801 - 5603

EJBI

European Journal for Biomedical Informatics

Volume 7 (2011), Issue 2

An Official Journal of the European Federation for Medical Informatics

www.ejbi.eu

Aims and Scope

The European Journal for Biomedical Informatics reacts on the great European need to share the information in the multilingual and multicultural European area. The journal publishes peer-reviewed papers in English and other European languages simultaneously. This opens new possibilities for faster transfer of scientific-research pieces of knowledge to large international community of biomedical researchers, physicians, other health personnel and citizens.

The generally accepted translations of the English version of the paper are to the following European languages:

List of European languages	ISO 639-1 code
Albanian	sg
Armenian	hy
Azerbaijani	az
Belarusian	be
Bosnian	bs
Bulgarian	bg
Catalan	ca
Croatian	hr
Czech	cs
Danish	da
Dutch	nl
English	en
Estonian	et
Finnish	fi
French	fr
Georgian	ka
German	de
Greek	el
Hungarian	hu
Icelandic	is
Irish	ga
Italian	it
Kazakh	kk
Latvian	lv
Lithuanian	lt
Luxembourgish	lb
Macedonian	mk
Maltese	mt
Norwegian	no
Polish	pl
Portuguese	pt
Romanian, Moldavian, Moldovan	ro
Romansh	rm
Russian	ru
Serbian	sr
Slovak	sk
Slovenian	sl
Spanish	es
Swedish	sv
Turkish	tr
Ukrainian	uk

Editors and Management

Editorial Board: National Members

Editorial Board: Representatives of Cooperating Journals

Publisher

EuroMISE s.r.o.
Paprsková 330/15
CZ-14000 Praha 4
Czech Republic
EU VAT ID: Cz25666011

Office

EuroMISE s.r.o.
Paprsková 330/15
CZ-14000 Praha 4
Czech Republic

Contact

Karel Zvára
zvara@euromise.com
Tel: +420 226 228 904
Fax: +420 241 712 990

Instructions to Authors for the Preparation of Contributions

Abstract

The abstract should summarize the contents of the paper and should not exceed 250 words. Authors are requested to write a structured summary, adhering to the following headings: Background (optional), Objectives, Methods, Results, Conclusions.

Keywords

At the end of the Abstract, the contents of the paper should be specified by, at most, five keywords. We recommend using MeSH keywords.

Introduction

Authors are kindly requested to carefully follow all instructions on how to write a paper. In cases where the instructions are not followed, the paper will be returned immediately with a request for changes, and the editorial review process will only start when the paper has been resubmitted in the correct style.

Authors are responsible for obtaining permission to reproduce any copyrighted material and this permission should be acknowledged in the paper.

Authors should not use the names of patients. Patients should not be recognizable from photographs unless their written permission has first been obtained. This permission should be acknowledged in the paper.

In general the manuscript text (excluding summary, references, figures, and tables) should not exceed 5 000 words.

Kindly send the final and checked source and PDF files of your paper to manuscripts@ejbi.org. You should make sure that the LaTeX and the PDF files are identical and correct and that only one version of your paper is sent. Please note that we do not need the printed paper.

Checking the PDF File

Kindly assure that the Contact Volume Editor is given the name and email address of the contact author for your paper. The contact author is asked to check through the final PDF files to make sure that no errors have crept in during the transfer or preparation of the files. Only errors introduced during the preparation of the files will be corrected.

If we do not receive a reply from a particular contact author, within the timeframe given, then it is presumed that the author has found no errors in the paper.

Copyright Transfer Agreement

The copyright form may be downloaded from the "For Authors" section of the EJBI Website: `www.ejbi.org`. Please send your signed copyright form to the Contact Volume Editor, either as a scanned pdf or by fax or by courier. One author may sign on behalf of all the other authors of a particular paper. Digital signatures are acceptable.

Manuscript Preparation

You are strongly encouraged to use LaTeX 2_ε for the preparation of your manuscript. Only if you use LaTeX 2_ε can hyperlinks be generated in the online version of your manuscript. The LaTeX source of this instruction file for LaTeX users may be used as a template.

When you are not able to use LaTeX, please use MS Word or OO Writer and send us the unformatted text. Kindly follow just instructions about preparing figures, tables and references. These instructions are explained for you in the included MS Word document. We are going to convert your text into LaTeX instead of you.

If you use LaTeX together with our template file, `ejbi_template.tex`, your text is typeset automatically. Please do *not* change the preset fonts. Do not use your own macros, or styles.

Please use the commands `\label` and `\ref` for cross-references and the commands `\bibitem` and `\cite` for references to the bibliography, to enable us to create hyperlinks at these places.

Headings Headings should be capitalized (i.e. nouns, verbs, and all other words except articles, prepositions, and conjunctions should be set with an initial capital) and should be aligned to the left. Words joined by a hyphen are subject to a special rule. If the first word can stand alone, the second word should be capitalized.

Lemmas, Propositions, and Theorems The numbers accorded to lemmas, propositions, and theorems, etc. appear in consecutive order, starting with Lemma 1, and not, for example, with Lemma 11.

Figures and Tables

Attach figures and tables as separate files. Do not integrate them into the text. Do not save your table as an image file or insert a table into your manuscript text document as an image.

Basics of Graphic Composition Less is more! Avoid tables with columns of numbers. Summarise the main conclusion in a figure.

- Annotations belong in a (self-)explanatory legend, do not use headings in the figure, explain abbreviations in the legend.
- Label all axes.
- Use a uniform type size (we recommend Arial 10 point), and avoid borders around tables and figures.

Data Formats

- Submit graphics as a sharp printout as well as a file. The printout and the file must be identical.
- Submit the image file with clear labelling (e.g. Fig_1 instead of joint_ap).

Image Resolution Image resolution is the number of dots per width of 1 inch, the "dots per inch" (dpi). Printing images require a resolution of 800 dpi for graphics and 300 dpi for photographics.

Vector graphics have no resolution problems. Some programs produce images not with a limited number of dots but as a vector graphic. Vectorisation eliminates the problem of resolution. However, if halftone images ("photos") are copied into such a program, these images retain their low resolution.

If screenshots are necessary, please make sure that you are happy with the print quality before you send the files.

Figures and Tables in LaTeX For LaTeX users, we recommend using the *ejbi-figure* environment (Figure 1 shows an example). The lettering in figures should have a height of 2 mm (10-point type). Figures should be numbered and should have a caption which should always be positioned *under* the figures, in contrast to the caption belonging to a table, which should always appear *above* the table (see an example in Table 1). Short captions are centred by default between the margins and typeset automatically in a smaller font.

Table 1: Age, period, cohort modelling of coronary heart mortality, men, 30-74 yrs., Czech Republic, 1980-2004.

No.	Model	D	*df*	*p*-value
0	Interception	355388.0	44	<0.001
1	Age	15148.0	36	<0.001
2	Age-Drift	3255.5	35	<0.001
3a	Age-Age*Drift	2922.5	27	<0.001
3b	Age-Period	388.2	32	<0.001
3c	Age-Cohort	1872.6	24	<0.001
4	Age-Period-Cohort	28.7	21	0.121

Remark 1. In the printed volumes, illustrations are generally black and white (halftones), and only in exceptional cases, and if the author is prepared to cover the extra cost for colour reproduction, are coloured pictures accepted. Coloured pictures are welcome in the electronic version free of charge. If you send coloured figures that are to be printed in black and white, please make sure that they really are legible in black and white. Some colours as well as the contrast of converted colours show up very poorly when printed in black and white.

Formulas

Displayed equations or formulas are centred and set on a separate line (with an extra line or halfline space above and below). Displayed expressions should be numbered for reference. The numbers should be consecutive within each section or within the contribution, with numbers enclosed in parentheses and set on the right margin – which is the default if you use the *equation* environment, e.g.

$$\psi(u) = \int_o^T \left[\frac{1}{2} \left(\Lambda_o^{-1} u, u \right) + N^*(-u) \right] dt \, . \qquad (1)$$

Please punctuate a displayed equation in the same way as the ordinary text but with a small space before the end punctuation.

Footnotes

The superscript numeral used to refer to a footnote appears in the text either directly after the word to be discussed or – in relation to a phrase or a sentence – following the punctuation sign (comma, semicolon, or period). Footnotes should appear at the bottom of the normal text area, with a line of about 2 cm set immediately above them.[1]

[1] The footnote numeral is set flush left and the text follows with the usual word spacing.

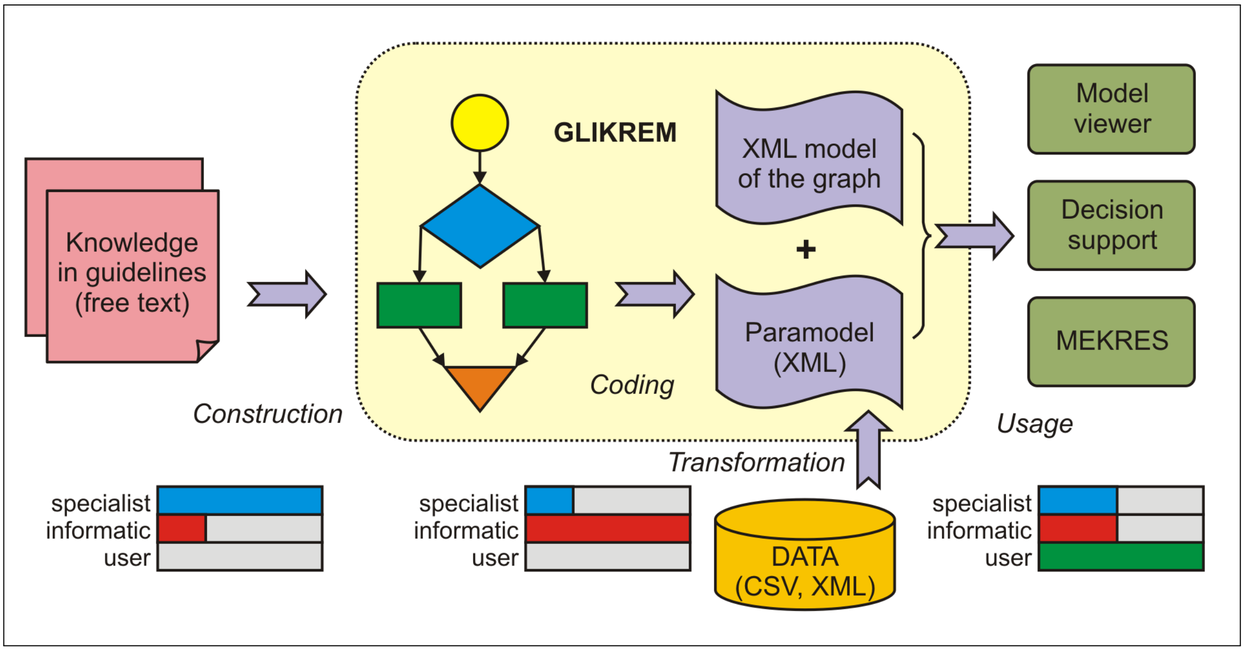

Figure 1: Construction, coding and use of GLIKREM.

Program Code

Program listings or program commands in the text are normally set in a typewriter font, e.g. CMTT10 or Courier.

Citations

The list of references is headed "References" and is not assigned a number. The list should be set in small print and placed at the end of your contribution, in front of the appendix, if one exists. Please do not insert a pagebreak before the list of references if the page is not completely filled. An example is given at the end of this information sheet.

For citations in the text please use square brackets and consecutive numbers: [1], [2, 3, 4]...

In the text number the references consecutively in the order in which they first appear. Use the style, which is based on the formats used by the US National Library of Medicine in MEDLINE (sometimes called the "Vancouver style"). For details see the guidelines from the International Committee of Medical Journal Editors (http://www.nlm.nih.gov/bsd/uniform_requirements.html).

Page Numbering and Running Heads

Please do not set running heads or page numbers.

Acknowledgements

Scientific advice, technical assistance, and credit for financial support and materials may be grouped in a section headed Acknowledgements that will appear at the end of the text (immediately after the Conclusions section).

The heading should be treated as a subsubsection heading and should not be assigned a number.

In case that a financial support of the paper development (e.g. sponsors, projects) is acknowledged, in the year 2012 the fee of 50 EUR will be charged by Publisher. The accepted peer-reviewed papers with an acknowledgement of a financial support, where the fee was not paid, will be published free of charge, but the financial acknowledgement will be withdrawn.

EJBI Online

The online version of the full volume will be available at `www.ejbi.org`.

References

[1] Blobel B. Architectural Approach to eHealth for Enabling Paradigm Changes in Health. Methods Inf Med. 2010; 49(2): 123–134.

[2] Kalina J. Robustní analýza obrazu obličeje pro genetické aplikace. EJBI [Internet]. 2010 [cited 2011 Jun 28]; 6(2): cs95–cs102. Available from: http://www.ejbi.eu/articles/201012/47/2.html

[3] van Bemmel JH, Musen M, editors. Handbook of Medical Informatics. Heidelberg: Springer; 1997.

[4] Zvarova J, Zvara K. e3Health: Three Main Features of Modern Healthcare. In: Moumtzoglou A, Kastania A. E-Health Systems Quality and Reliability: Models and Standards, Hershey: IGI Global; 2010; 18–27.

Contents

Education in Medical Informatics and Bioinformatics

J. Mantas[1], **A. Hasman**[2]

[1] Health Informatics Laboratory, National and Kapodistrian University of Athens, Athens, Greece

[2] Dept. of Medical Informatics, AMC-UvA, Amsterdam, the Netherlands

Healthcare professionals are increasingly confronted in their work practice with computer-based applications, like the EPR and clinical decision support systems. The use of such systems may sometimes provide problems to clinicians but training in the use of these systems usually is enough to use the system without problems. But being able to use an information system does not imply that no problems will be encountered anymore. Problems can occur when the use of the system does not fit with the workflow of clinicians. When developing information systems clinicians should play a role. However, clinicians only can contribute when they also have enough knowledge about biomedical and health informatics (BMHI). So at least some of the clinicians should get education in this field. But it becomes increasingly clear that all clinicians should be introduced to BMHI. Since medical informatics is sometimes considered to be about computer technology the conclusion was that clinicians do not need such an education. Martin-Sanches and Gray [1] correctly state that this interpretation of BMHI devalues the academic discipline. Clinicians need to be taught medical informatics, but medical informatics interpreted as the science of information, information being data plus meaning. The question then is what subjects should be taught to medical students.

IMIA, the International Medical Informatics Association, has recently published the first Revision of the Recommendations on Education in Biomedical and Health Informatics [2]. It supersedes the original Recommendations that were published 11 years ago. BMHI has changed so rapidly that the Revision was badly needed. The IMIA recommendations focus on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology. The IMIA recommendations describe the educational needs using a three dimensional framework. What needs to be taught depends on

1. which type of professionals in healthcare (e.g. physicians, nurses, medical informaticians) one wants to produce,
2. which type of specialization one wants to attain (e.g. IT users, medical informatics specialists) and
3. in which stage of their career (bachelor, master, doctorate) the students are.

Recommendations are given for courses/course tracks in biomedical and health informatics as part of educational programs in medicine, nursing, healthcare management, dentistry, pharmacy, public health, health record administration and informatics/computer science as well as for dedicated programs in BMHI.

This special issue on Education in Medical Informatics contains a number of articles discussing and evaluating BMHI curricula in different countries. Most contributions deal with the medical informatics education for medical students.

In the first contribution Gray et al [3] focus on the education of health professionals in BMHI. They review how clinical informatics education has worked in the past and provide future directions. They conclude that the peer-reviewed literature offers a variety of recommendations on what to teach and why to teach it. However, there is a paucity of literature that goes beyond learning needs, competency specifications and content outlines. According to them more should be published about what is involved in making such education a reality and on the experience of staff and students who participate in it.

Martin-Sanches and Gray [1] propose a definition of BMHI as the science of information applied to or studied in the context of biomedicine. The authors describe several misconceptions about this scientific and professional discipline. They describe the current international situation of BMHI with respect to education and research. Then they analyse the situation in Spain and Australia.

Behrends et al [4] describe the problems they encountered when they tried to integrate the topic of medical informatics in the third year of a new medical curriculum. Medical students appeared to have misconceptions about the role of medical informatics and did not understand why they had to deal with this subject. To alleviate the situation they used the feedback given by students to improve the way medical informatics was taught. The evaluation of the education by the students improved to a satisfactory level.

Kern et al [5] describe the medical informatics program and training at the School of Medicine of the University of Zagreb, Croatia. They conclude that medical students are starting to recognize the role of information in their future profession.

Zvarova et al [6] describe undergraduate and doctoral degree studies in biomedical informatics at the Faculties of Medicine of the Charles University in Prague, Czech Republic. They also describe e-learning tools like interactive books, wiki teaching material, Web 2.0-based e-learning tools and tools for assessing knowledge.

Bari et al [7] describe the most important factors influencing medical informatics education in general, in Hungary and at their faculty in particular. They emphasize that even with limited resources it is possible to create and maintain valuable training programs especially when trans-border cooperation is possible.

Borycki et al [8] describe a new double degree graduate program in health informatics and nursing. The program was designed to prepare nurses with graduate level competencies in both nursing and health informatics.

Adoption of SNOMED CT has not been as quick and easy as many people had hoped or expected. One reason is lack of education and hence understanding of what SNOMED CT does and how it works. Conley and Benson [9] set out to answer the question "who needs to know what" about SNOMED CT to help establish priorities for UK higher education.

The contributions are well written and we hope that this special issue will provide readers with more insight in the way BMHI education is organized in various countries and what the problems and opportunities in setting up programs are.

The editors of this issue would like to acknowledge and thank the Editor-in-Chief of EJBI for overseeing the process of preparing this special issue.

References

[1] Martin-Sanchez F., Gray K.: Education, Research and Professionalism in Biomedical and Health Informatics: Myths, Realities And Proposals for the Future. EJBI 2011; 7(1):64–71

[2] Mantas J. et al.: Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics, First Revision. Methods of Information in Medicine 2010; 49 2: 105-120

[3] Gray K., Dattakumar A., Maeder A., Chenery H.: Educating Future Clinicians about Clinical Informatics: A Review of Implementation and Evaluation Cases. EJBI 2011; 7(1):48–57

[4] Behrends M., von Jan U., Paulmann V., Matthies H. K.: Teaching Medical Informatics to Medical Students What are the Challenges in a Model Curriculum? EJBI 2011; 7(1):25–30

[5] Kern J., Fišter K.: Medical Informatics Meets Medical Education: the Croatian Experience. EJBI 2011; 7(1):58–63

[6] Zvárová J. et al.: Biomedical Informatics Education at Charles University in Prague for Undergraduate and Doctoral Degree Studies. EJBI 2011; 7(1):72–78

[7] Bari F. Forczek E., Hantos Z.: E-Health Resources in the Graduate and Postgraduate Medical Education in Hungary. EJBI 2011; 7(1):19–24

[8] Borycki E., Frisch N., McIntyre M., Kushniruk A.: Design of an Innovative Double Degree Graduate Program in Health Informatics and Nursing: Bridging Nursing and Health Informatics. EJBI 2011; 7(1):31–39

[9] Conley E., Benson T.: SNOMED CT: Who Needs to Know What? EJBI 2011; 7(1):40–47

Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics – First Revision

J. Mantas; E. Ammenwerth; G. Demiris; A. Hasman; R. Haux; W. Hersh; E. Hovenga; K. C. Lun; H. Marin; F. Martin-Sanchez; G. Wright

(IMIA Recommendations on Education Task Force)

Reprinted from Methods Inf Med 2010; 49: 105–120

Abstract

Objective: The International Medical Informatics Association (IMIA) agreed on revising the existing international recommendations in health informatics /medical informatics education. These should help to establish courses, course tracks or even complete programs in this field, to further develop existing educational activities in the various nations and to support international initiatives concerning education in biomedical and health informatics (BMHI), particularly international activities in educating BMHI specialists and the sharing of courseware.
Method: An IMIA task force, nominated in 2006, worked on updating the recommendations' first version. These updates have been broadly discussed and refined by members of IMIA's National Member Societies, IMIA's Academic Institutional Members and by members of IMIA's Working Group on Health and Medical Informatics Education.
Results and Conclusions: The IMIA recommendations center on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology. The educational needs are described as a threedimensional framework. The dimensions are: 1) professionals in health care (e.g. physicians, nurses, BMHI professionals), 2) type of specialization in BMHI (IT users, BMHI specialists), and 3) stage of career progression (bachelor, master, doctorate). Learning outcomes are defined in terms of knowledge and practical skills for health care professionals in their role a) as IT user and b) as BMHI specialist. Recommendations are given for courses /course tracks in BMHI as part of educational programs in medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and informatics /computer science as well as for dedicated programs in BMHI (with bachelor, master or doctor degree).
To support education in BMHI, IMIA offers to award a certificate for high-quality BMHI education. It supports information exchange on programs and courses in BMHI through its Working Group on Health and Medical Informatics Education.

Keywords

Medical informatics, health informatics, biomedical informatics, education, recommendations, International Medical Informatics Association, IMIA

Correspondence to:

John Mantas
Health Informatics Lab, University of Athens
Address: 123, Papadiamantopoulou Street, 11527 Athens, Greece
E–mail: jmantas@nurs.uoa.gr

EJBI 2011; 7(2):xx–yy

1 Introduction

The first version of the "Recommendations of the International Medical Informatics Association (IMIA) on education in health and medical informatics" [1] has been widely used. Because of the tremendous progress in and the evolution of the field of health and biomedical informatics, the contents of those recommendations were, however, not fully uptodate. As there is still a continuous need for such recommendations, a revision was necessary.

The revised version, presented here, is based on the original recommendations and the fundamental work following those recommendations ([1, 3, 4, 5, 6, 7, 8, 9] and Table 1 in Section 1.2).

There is increasing evidence that health information technology (HIT) improves health, health care, public health, and biomedical research. A number of recent systematic reviews have documented the evidence in favor of clinical decision support [10], information and communication technology (IT) interventions [11], and telemedicine [12]. This has led to widespread adoption of HIT around the world [13]. In addition to a growing range of research and application fields in biomedical and health informatics (BMHI) [14, 15], there is also growth in related areas of BMHI, such as clinical research informatics [16, 17, 18] and bioinformatics [19]. The growth of HIT has also led to the recognition of the need for educational programs to train professionals to develop, implement, and evaluate these systems. While this need has been recognized worldwide [20], there have been few international efforts with some notable exceptions [21, 22].

1.1 Why Do We Need Biomedical and Health Informatics Education?

Despite the documented benefits, there are still barriers to HIT in clinical settings, including a mismatch of return on investment between those who pay and those who benefit, challenges to ameliorate workflow in clinical settings, lack of standards and interoperability, and concerns about privacy and confidentiality [23, 24, 25]. Another barrier, lesser studied and quantified but increasingly recognized, is the lack of characterization of the workforce and its training needed to most effectively implement HIT systems [26, 27].

An additional challenge is that there are various definitions of the field of BMHI [26, 28, 29]. Furthermore, the field has difficulty agreeing on the adjective in front of the word informatics (i.e., medical, biomedical, and/or health) as well as whether a practitioner should be called an informaticist or informatician (this paper uses the latter). We also do not know where pure IT ends and informatics begins. For example, the individual who installs applications on a desktop computer in a hospital probably does not need formal training in informatics, although the CIO and his or her project leaders certainly do. This has led to calls for BMHI to become a professional discipline [30] and for it to acquire the attributes of a profession, such as a welldefined set of competencies, certification of fitness to practice, shared professional identity, life-long commitment, and a code of ethics [31].

A number of efforts to establish formal certification have been and are underway. For example, in Germany, medical informatics courses are mandatory for medical students since the 1970s [32]. In the US, certification in nursing informatics has been available for over a decade [33]. More recently, the American Medical Informatics Association (AMIA) has proposed a plan for a physician board sub-specialization, which will be followed for other nonphysician doctorally prepared individuals [34, 35].

Despite these challenges, a number of organizations have deemed competence in BMHI to be important. Competencies in the field have been developed for a variety of disciplines within BMHI. In Table 1 some major publications on the development of such competencies are listed as examples.

1.2 IMIA Recommendations for Biomedical and Health Informatics Education

There are many opportunities worldwide for obtaining education in this field. In some countries, there are extensive educational components in BMHI at different levels of education and for the different health care professions. Increasingly dedicated BMHI programs exist (i.e. organized, structured sets of course offerings aimed at preparing participants for specific career paths and culminating in a BMHI degree, diploma or leaving certificate). Many other countries have not, or at least not sufficiently, established such opportunities until now, with all the consequences concerning the quality and effectiveness of health care. Lists of educational programs have been made available at a variety of websites, e.g.:

- BMHI programs world wide [73] (University of Freiburg, Germany),
- BMHI programs in [74] and outside [75] North America (AMIA).

In 2007 IMIA, the International Medical Informatics Association [76], endorsed and published its strategic plan “Towards IMIA 2015” [77, 78, 79, 80]. Education in BMHI was listed among its six core-subject- focused ‘sectors’. Recognizing that the original version of the IMIA recommendations for education had become outdated, in 2006 a task force was established under the auspices of IMIA’s Working Group on Health and Medical Informatics Education “to consider and undertake any necessary work to update the IMIA Recommendations on Education in Health and Medical Informatics” [81]. These recommendations will continue to stimulate the further development of existing educational activities in the various nations and to support international initiatives concerning education in BMHI.

Because a variety of educational and health care systems exist all over the world, programs, courses and course tracks in BMHI may vary in different countries. In spite of this variability, basic similarities in BMHI education can be identified and used as a framework for recommendations. Such recommendations are also necessary for enabling an international exchange of students and teachers and for establishing international programs.

The IMIA recommendations, presented here, should be regarded as a framework for national initiatives in BMHI education, and for constituting international programs and exchange of students and teachers in this field. They shall also encourage and support the sharing of courseware.

Table 1: Some major publications on competencies in biomedical and health informatics.

Organization (Reference)	Year	Discipline
University of Heidelberg and the University of Applied Sciences Heilbronn medical informatics program [36, 37]	1972	dedicated BMHI programs
German Association for Medical Informatics, Biometry and Epidemiology (gmds) and German Society for Computer Science (Reisensburg Conference) [38, 39]	1973	BMHI and computer science
Association for Computing Machinery [40]	1978	BMHI and computer science
Association of the Medical Colleges [41]	1984	BMHI and medicine
gmds [42]	1992	BMHI in general
Concerted Action on Education and Training in Health Care Informatics (EDUCTRA) [43]	1992	BMHI for health professionals
Council of Europe Committee of Ministers [44]	1995	BMHI for health professionals
NIGHTINGALE project [45, 46]	1996	nursing informatics
IT-EDUCTRA project [43]	1996	BMHI for health professionals
English National Board for Nursing, Midwifery and Health Visiting [47]	1996	BMHI for nurses, midwives and health visitors
National Advisory Council on Nurse Education and Practice [48]	1996	midwives and health visitors
Association of American Medical Colleges [49]	1999	BMHI and medicine
International Medical Informatics Association [1]	1999	BMHI in general
Schleyer [50]	1999	dental informatics
UK National Health Service [51]	2001	BMHI in general
Staggers et al. [52]	2001	nursing informatics
Covvey et al. [53]	2001	BMHI in general
Mantas and Hasman [54]	2001	nursing informatics
O'Caroll et al. [55]	2002	BMHI for public health (PH) professionals
Curran [56]	2003	nursing informatics
American College of Medical Informatics [57]	2004	bioinformatics
American Health Information Management Association (AHIMA) [58]	2004	health information management
Hovenga and Mantas [20]	2004	BMHI in general
Hovenga and Garde [59]	2006	health informatics
Ivanitskaya et al. [60]	2006	health information literacy
AHIMA [61]	2007	health information management
Canadian Health Informatics Association [62]	2007	health informatics
Medical Library Association [63]	2007	health science librarians
Pigott et al. [64]	2007	health informatics
Huang [65]	2008	BMHI in general
AMIA and AHIMA [66]	2008	EHR Clinical users
Gassert [67]	2008	Nursing informatics
Karras et al. [68]	2008	PH informatics
AMIA [69]	2009	clinical informatics
AMIA-OHSU 10 x 10 Course [70]	2009	BMHI in general
TIGER Nursing Informatics [71]	2009	Nursing Informatics
Office of the National Coordinator for Health IT [72]	2009	EHR adoption

2 General Considerations

2.1 Key Principles of the IMIA Recommendations

In order to provide good-quality health care, training and education in biomedical and health medical informatics is needed:

H for various Health care professions,

E in different modes of Education,

A with different, Alternate types of specialization in BMHI, and

L at various Levels of education, corresponding to respective stages of career progression. There must be

T qualified Teachers to provide BMHI courses, which lead to

H recognized qualifications for biomedical and Health informatics positions.

In more detail, 'HEALTH' means:

H Practically all professionals in health care should, during their studies, be confronted with BMHI education: e.g. physicians, nurses, pharmacists, dentists, health care managers, health record administrators, and also health and medical informaticians who are graduates from specialized programs in BMHI. Computer scientists/informaticians and other scientists (e.g. engineers), who intend to work in the fields of medicine and health care, also need BMHI education.

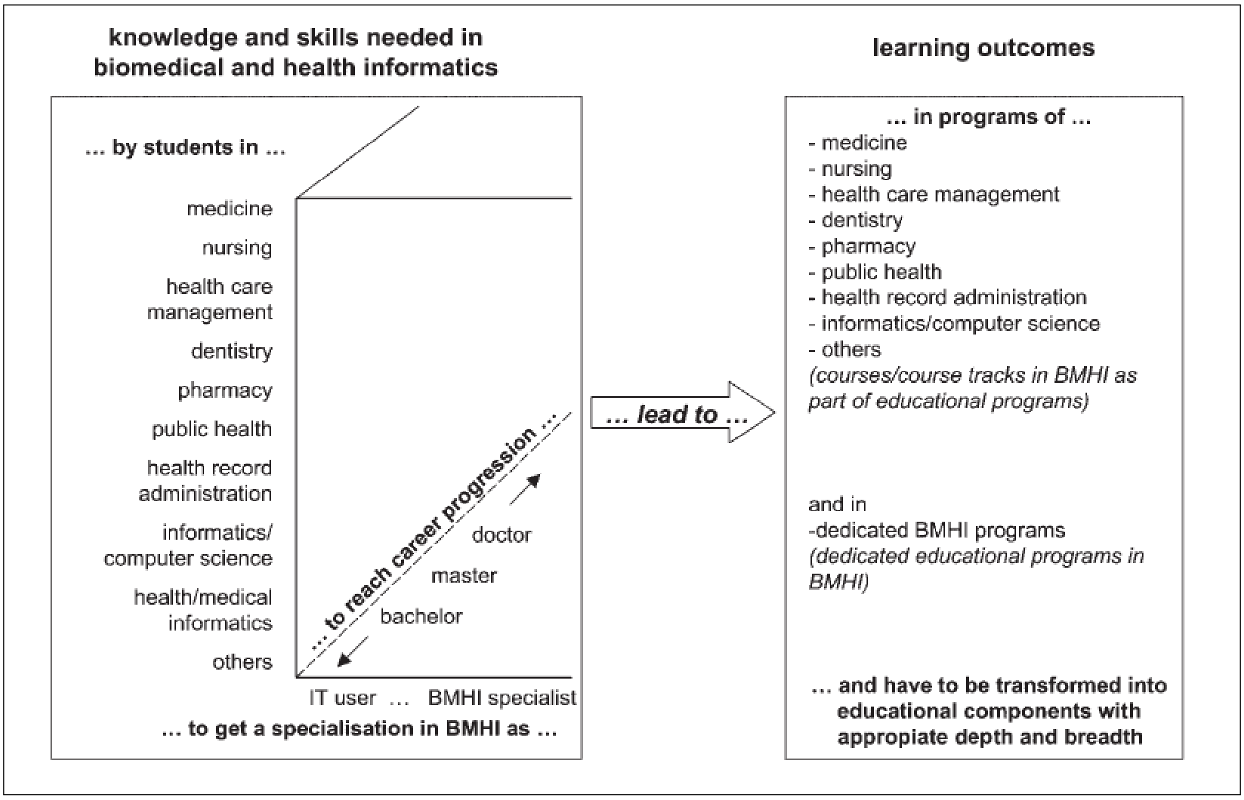

Figure 1: Structural outline of the IMIA recommendations on education in biomedical and health informatics (BMHI): knowledge and skills needed in BMHI by students in health care, to get a specialization in BMHI and to reach a career progression lead to learning outcomes in programs, and have to be transformed into educational components with appropriate depth and breadth.

E Various education methodologies are needed to provide the required theoretical knowledge, practical skills and mature attitudes. In addition to traditional classroom-based models, there are many different models of flexible, distance and supported open learning to be considered. The explosive growth of the Internet and World Wide Web, videoconferencing, document sharing and social networking platforms and applications are additionally having great impacts on all educational methodologies, and in particular will favor flexible and distance learning including both synchronous and asynchronous communication between instructors and students. Inter-university collaborations might also facilitate curricular choice.

A Alternate routes to different types of specialization in BMHI will depend on career choice. The majority of health care professionals (e.g. physicians, nurses) need to know how to efficiently and responsibly use information and communication technology, but only a few will choose to have accredited specialization in this field. They should, however, also be able to acquire an additional specialist qualification in BMHI as part of their chosen career development. BMHI specializations may be different to suit the various types of health care professionals. Finally, it should also be possible to acquire specialist qualifications in BMHI via specific BMHI programs leading to accreditation at different levels, e.g. master or PhD.

L Every profession in health care even at an early stage needs some core BMHI knowledge. Different levels of education, respectively stages of career progression, (bachelor, master, and doctor) have different BMHI education needs according to experience, professional role and responsibility. A junior professional uses information differently compared to a senior professional. There are specialized BMHI university programs but BMHI instruction could also be integrated within other professional educational programs (medicine, nursing, informatics /computer science, etc.). Thus educational components will vary in depth and breadth to suit specific student groups. Subsequent continuous education programs in BMHI also need to be available.

T The content and delivery of BMHI courses and programs must be of good quality. Teachers of BMHI courses must have adequate and specific competence in this field.

H There must be recognized qualifications in BMHI for positions in this field. Accreditation of educational

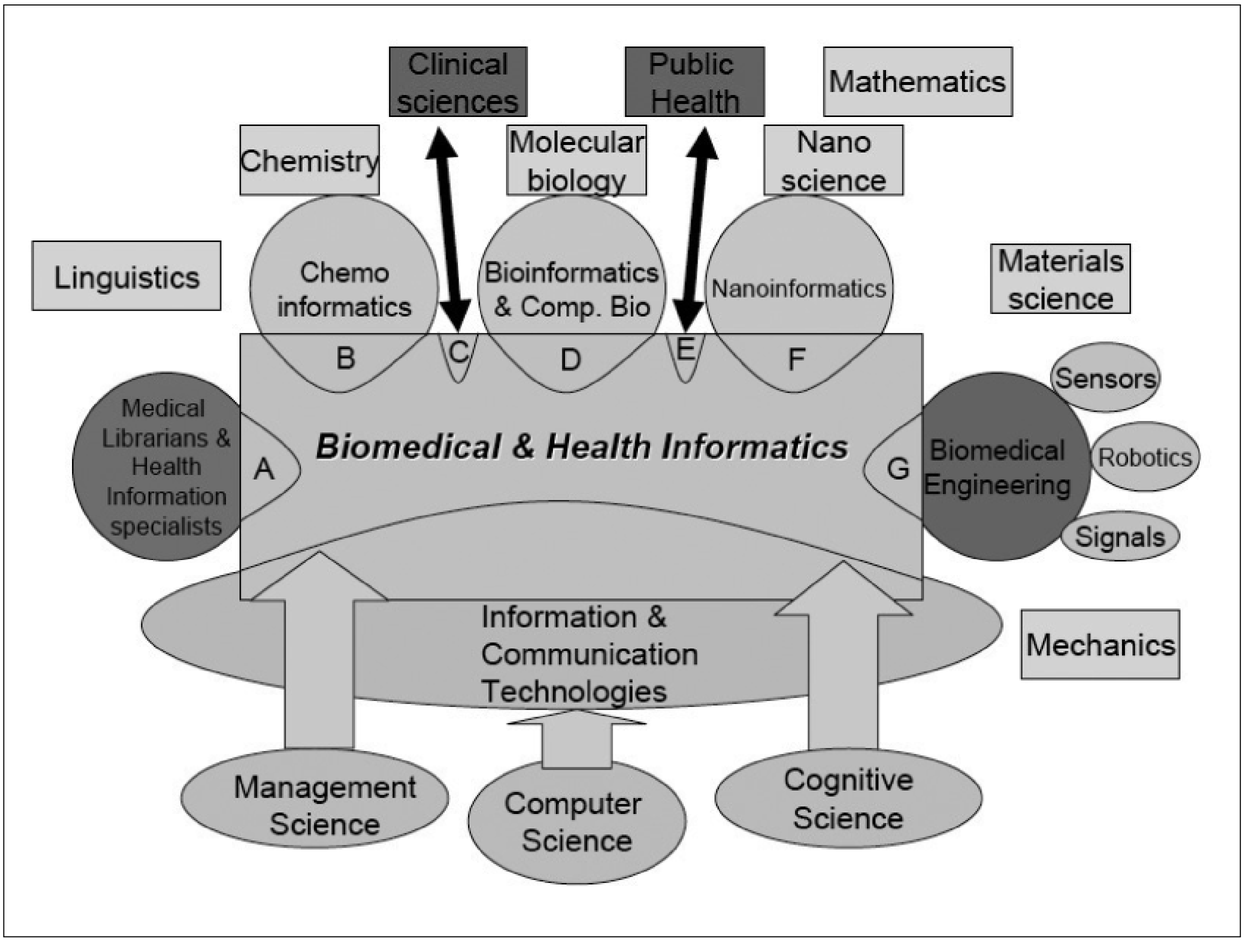

Figure 2: Biomedical and health informatics and related fields. Overlapping areas: A – medical information science, B – medical chemoinformatics, C – clinical informatics, D – medical (translational) bioinformatics, E – public health informatics, F – medical nanoinformatics, G – medical imaging and devices.

content and competence is required, to eventually have recognition on an international basis.

2.2 Structural Outline of the IMIA Recommendations

The IMIA recommendations center on educational needs for health care professionals to acquire knowledge and skills in information processing and information and communication technology as it is needed and used in medicine and health care. The educational needs are described as a three-dimensional framework with dimensions 'professional in health care', 'type of specialization in BMHI' and 'stage of career progression' (Fig. 1).

Figure 1 points out that if one is studying a certain discipline (e.g. medicine to receive a bachelor degree), then the IMIA recommendations suggest that in their study, all these students should get a minimum of education in BMHI, so that they are able to efficiently use information and communication technology (IT users).

On the other side, candidates may want to prepare for careers as BMHI specialists. The study of BMHI for these specialists is somewhat different. Here we have to interpret Figure 1 in the sense that learning outcomes (also being given in Table 2 and further explained in Sections 4 and 5) are defined to get a bachelor, master or doctor degree in BMHI. Per definition this predefines a BMHI specialist. There are obviously different ways to become a qualified BMHI specialist.

3 Recommendations for Learning Outcomes in Biomedical and Health Informatics

Interesting differences exist both within and between countries and programs with regard to structures of curricula and expected learning outcomes. Several initiatives have been launched in the last years to define some standardized content of BMHI curricula, aiming at developing sample informatics curricula.

A clear trend in curriculum design is the integration of disciplines closely related to the core field of BMHI, such as biomedical engineering, medical information sciences, molecular biology or nanosciences. Those fields share knowledge, methods and tools with BMHI. Figure 2 highlights and describes the most important related disciplines. For further discussion of this issue, see e.g. also [82, 83, 84].

The learning outcomes, presented in Section 3, will integrate those overlapping areas as optional elements, depending on the focus of the respective program. This as-

Table 2: Recommended and optional learning outcomes in terms of levels of knowledge and skills for professionals in health care either in their role as IT users or as BMHI specialists. Additional recommendations, specific for a certain educational program, will be added in Sections 4 and 5. Recommended level of knowledge and skills: + = introductory. ++ = intermediate. +++ = advanced.

Knowledge/Skill – Domain		**– Level**	
		IT user	*BMHI specialist*
(1) Biomedical and Health Informatics Core Knowledge and Skills			
1.1	Evolution of informatics as a discipline and as a profession	+	+
1.2	Need for systematic information processing in health care, benefits and constraints of information technology in health care	++	++
1.3	Efficient and responsible use of information processing tools, to support health care professionals' practice and their decision making	++	++
1.4	Use of personal application software for documentation, personal communication including Internet access, for publication and basic statistics	++	++
1.5	Information literacy: library classification and systematic health related terminologies and their coding, literature retrieval methods, research methods and research paradigms	++	++
1.6	Characteristics, functionalities and examples of information systems in health care (e.g. clinical information systems, primary care information systems, etc.)	+	+++
1.7	Architectures of information systems in health care; approaches and standards for communication and cooperation and for interfacing and integration of component, architectural paradigms (e.g. service-oriented architectures)		++
1.8	Management of information systems in health care (health information management, strategic and tactic information management, IT governance, IT service management, legal and regulatory issues)	+	+++
1.9	Characteristics, functionalities and examples of information systems to support patients and the public (e.g. patient-oriented information system architectures and applications, personal health records, sensor-enhanced information systems)	+	++
1.10	Methods and approaches to regional networking and shared care (eHealth, health telematics applications and inter-organizational information exchange)	+	++
1.11	Appropriate documentation and health data management principles including ability to use health and medical coding systems, construction of health and medical coding systems	+	+++
1.12	Structure, design and analysis principles of the health record including notions of data quality, minimum data sets, architecture and general applications of the electronic patient record/electronic health record	+	+++
1.13	Socio-organizational and socio-technical issues, including workflow/process modelling and reorganization	+	++
1.14	Principles of data representation and data analysis using primary and secondary data sources, principles of data mining, data warehouses, knowledge management	+	++
1.15	Biomedical modelling and simulation		+
1.16	Ethical and security issues including accountability of health care providers and managers and BMHI specialists and the confidentiality, privacy and security of patient data	+	++
1.17	Nomenclatures, vocabularies, terminologies, ontologies and taxonomies in BMHI	+	++
1.18	Informatics methods and tools to support education (incl. flexible and distance learning), use of relevant educational technologies, incl. Internet and World Wide Web		+
1.19	Evaluation and assessment of information systems, including study design, selection and triangulation of (quantitative and qualitative) methods, outcome and impact evaluation, economic evaluation, unintended consequences, systematic reviews and meta-analysis, evidence-based health informatics		++
(2) Medicine, Health and Biosciences, Health System Organization			
2.1	Fundamentals of human functioning and biosciences (anatomy, physiology, microbiology, genomics, and clinical disciplines such as internal medicine, surgery, etc.)	+	+
2.2	Fundamentals of what constitutes health, from physiological, sociological, psychological, nutritional, emotional, environmental, cultural, spiritual perspectives and its assessment	+	+
2.3	Principles of clinical/medical decision making and diagnostic and therapeutic strategies	+	++
2.4	Organisation of health institutions and of the overall health system, interorganizational aspects, shared care	+	+++
2.5	Policy and regulatory frameworks for information handling in health care		+
2.6	Principles of evidence-based practice (evidence-based medicine, evidence-based nursing, ...)	+	+
2.7	Health administration, health economics, health quality management and resource management, patient safety initiatives, public health services and outcome measurement	+	++
continued on next page			

continued from previous page

Knowledge/Skill – Domain		– Level	
		IT user	*BMHI specialist*
(3) Informatics/Computer Science, Mathematics, Biometry (continued)			
3.1	Basic informatics terminology like data, information, knowledge, hardware, software, computer, networks, information systems, information systems management	+	+++
3.2	Ability to use personal computers, text processing and spread sheet software, easy-to-use database management systems	++	+++
3.3	Ability to communicate electronically, including electronic data exchange, with other health care professionals, internet/intranet use	++	+++
3.4	Methods of practical informatics/computer science, especially on programming languages, software engineering, data structures, database management systems, information and system modelling tools, information systems theory and practice, knowledge engineering, (concept) representation and acquisition, software architectures		+++
3.5	Methods of theoretical informatics/computer science, e.g. complexity theory, encryption/security		++
3.6	Methods of technical informatics/computer science, e.g. network architectures and topologies, telecommunications, wireless technology, virtual reality, multimedia		++
3.7	Methods of interfacing and integration of information system components in health care, interfacing standards, dealing with multiple patient identifiers		++
3.8	Handling of the information system life cycle: analysis, requirement specification, implementation and/or selection of information systems, risk management, user training	+	+++
3.9	Methods of project management and change management (i.e. project planning, resource management, team management, conflict management, collaboration and motivation, change theories, change strategies)	+	+++
3.10	Mathematics: algebra, analysis, logic, numerical mathematics, probability theory and statistics, cryptography		++
3.11	Biometry, epidemiology, and health research methods, including study design		++
3.12	Methods for decision support and their application to patient management, acquisition, representation and engineering of medical knowledge; construction and use of clinical pathways and guidelines	+	+++
3.13	Basic concepts and applications of ubiquitous computing (e.g. pervasive, sensor-based and ambient technologies in health care, health enabling technologies, ubiquitous health systems and ambient assisted-living)		+
3.14	Usability engineering, human-computer interaction, usability evaluation, cognitive aspects of information processing		++
(4) Optional Modules in BHMI and from Related Fields			
4.1	Biomedical imaging and signal processing		+ – +++
4.2	Clinical/Medical bioinformatics and computational biology		+ – +++
4.3	Health-enabling technologies, ubiquitous health systems and ambient-assisted living		+ – +++
4.4	Health information sciences		+ – +++
4.5	Medical chemoinformatics		+ – +++
4.6	Medical nanoinformatics		+ – +++
4.7	Medical robotics		+ – +++
4.8	Public health informatics		+ – +++

sures that graduates from BMHI programs know at least the basics of those related disciplines, and to give various programs the flexibility to focus on one or more of those overlapping areas, depending on the cultural, scientific and technical context of the institution.

For education in BMHI two kinds of major learning outcomes can be identified. They specify the

1. Learning outcomes for all health care professionals in their role as IT users: Enabling health care professionals to efficiently and responsibly use information and knowledge processing methodology and information and communication technology. These learning outcomes need to be included in all undergraduate curricula, leading to a health care professional qualification.
   On the other hand there are:
2. Learning outcomes for BMHI specialists: Preparing graduates for careers in BMHI in academic, health care (e.g. hospital, primary care), government or industrial settings. These learning outcomes need to be included in all curricula, leading to a qualification as specialist in BMHI.

Obviously, between the specialization of a health care professional as IT user and a health care professional as a BMHI specialist, various levels concerning depth and breadth of learning outcomes exist. Some programs may focus on either health care professionals or on health informatics specialists.

Other programs may focus on a kind of intermediary level, where students are educated to communicate with physicians and nurses as IT users on one side and health informatics specialists on the other side.

The learning outcomes define the levels of knowledge and skills needed. The desired outcomes determine the educational components either in courses/course tracks in BMHI as part of educational programs or as dedicated programs in BMHI.

Table 2 contains the list of learning outcomes, recommended by IMIA. The knowledge and skill levels are classified into the domain areas:

1. BMHI core knowledge and skills,
2. medicine, health and biosciences, health system organization,
3. informatics/computer science, mathematics, biometry,
4. optional modules in BMHI and from related fields.

In order to achieve the learning outcomes mentioned above, their educational components should be considered for inclusion into the respective educational programs. Knowledge and skills, which are described in part 4, are optional and are recommended, e.g. if the research profile of the university/school offering a program includes these fields and if it fits well into the program.

All health care professional graduates should, in their role as IT users, have the levels of knowledge and skills mentioned for IT users. Analogously, those professionals in health care, being BMHI specialists, should have the levels of knowledge and skills specified for them.

The levels of knowledge and skills mentioned may particularly work well for developed, industrialized countries, with high levels of access to, and use of, information technology, and which have highly developed health care infrastructures. Countries in transition may at the beginning have the need to adapt them with regard to the level of technology. The principles of BMHI, however, can still be taught, developed and applied in the absence of high levels of information and communication technology.

Recommendations, either specific for certain courses or course tracks in BMHI as part of educational programs or specific for dedicated educational programs in BMHI are mentioned in Sections 4 and 5.

4 Recommendations for Courses/Course Tracks in Biomedical and Health Informatics as Part of Educational Programs

4.1 General Remarks

Educational course components in BMHI should be tailored to the student's advancement and where possible be made relevant for and used to support a given stage of student progression. For example, teaching about the patient record for students of medicine should be introduced after the student has gained some clinical experience, but not too late so that students can benefit from this knowledge in the latter stages of their clinical training.

Due to the aforementioned large variety, there exist different perspectives for BMHI education. For BMHI specialists we especially can distinguish between a more informatics-based and a more health carebased approach to BMHI education, with a variety of combinations in-between. It is important to recognize the need for teamwork as all health informatics projects require input from more than one person each with their own unique skill set, so that the team as whole is able to address all project aspects in a cohesive and coordinated manner.

The objective of an informatics-based approach to BMHI is to focus on the machine processing of data, information and knowledge in health care and medicine with a strong emphasis on the need for advanced knowledge and skills of BMHI, of workflow, people and organizational aspects, of mathematics, as well as of theoretical, practical and technical informatics/computer science, especially semantic interoperability, ontology-based software engineering and its relationship with effective and safe data, information and knowledge processing and representation. Health care problems, however, can be treated cooperatively with physicians and other health care professionals. In such an approach to BMHI education, knowledge and skills of informatics/computer science predominate, but must be applied with a sound knowledge of the business of providing healthcare services.

The objective of a health care-based approach to BMHI is again to focus on the machine processing of data, information and knowledge in health care and medicine requiring, apart from knowledge in BMHI, also knowledge in medicine or other health sciences to such an extent that can only be imparted within the scope of a medical or health science education. In such an approach to BMHI education, clinical knowledge and skills predominate but these must be applied within the BMHI context.

The recommendations given in Sections 4.2 and 4.3 for BMHI specialists are for health care-based approaches to BMHI. The recommendations in Sections 4.4 and 5.2 are oriented towards an informatics-based approach. With respect to educa tional progression, especially for a bachelor, master, and doctoral degree, the general distinctions in depth and breadth should be considered as mentioned in Section 5.

For specifying a student's workload, the European Credit Transfer and Accumulation System (ECTS) is used [85]. In ECTS a full academic year's student workload corresponds to 60 ECTS credits.

4.2 Recommendations for Biomedical and Health Informatics Courses as Part of Medical, Nursing, Health Care Management, Dentistry, Pharmacy, and Public Health Programs

4.2.1 Courses/Course Tracks for IT Users

In order to achieve the levels of knowledge and skills in BMHI as recommended in Section 3 for IT users, the total student workload for educational components in BMHI should comprise at least four ECTS credits. Four ECTS credits can correspond, e.g., to approx. 40 hours of lectures, exercises and practical training at universities. A course, charged with four ECTS credits, may e.g. consist of a 3-hour/week lecture, given in one semester with 14 weeks of lecturing.

Specific examples from the work of the respective health professionals should be used. Emphasis should particularly be given to practical and simulated training.

The additional recommendations of this Section 4 may also apply to the programs of other professions in health care such as medical laboratory technicians, medical librarians, radiology technicians, dieticians, occupational therapists, etc., or for the programs allied health/clinical researchers studied. These people also need to know about the potentials and the risks of information processing in health care and should be able to efficiently use methods and tools of information processing and information and communication technology.

4.2.2 Courses/Course Tracks for BMHI Specialists

In order to achieve the levels of knowledge and skills in BMHI, as recommended in Section 3 for specialists, the student workload associated with these educational components in BMHI should be at least 60 ECTS credits, i.e. one year of full-time studies. This is similar to dedicated master programs in BMHI.

In addition to the 'core' knowledge and skills obtained in each program, the relative amount of student workload for the three knowledge and skills areas inside the health/medical informatics course track should approximately be as indicated in Table 3.

For all health care professionals domain area (2) should focus on health system organization, area (3) on practical informatics and project management. For nurses it should be possible that specialization can be included in a postgraduate nursing curriculum. For health care managers, knowledge and practical skills of information systems architectures, incl. characteristics required to achieve semantic interoperability and information systems/network management should particularly comprise work and information flow supporting enterprise functions for administration, controlling, quality management and executive decision making.

4.3 Recommendations for Biomedical and Health Informatics Courses as Part of Health Record Administration Programs

Within the past decade the discipline of health record administration (also denoted as health information management) has often enhanced its scope from document handling to managing health care information. Also the scope of practice has changed considerably.

For educating health record administrators, two different levels of education are recommended:

- A first level should cover introductory concepts and principles and assumes an introductory skill level. Students at this level take e.g. a two- or three-year course of study at a college level resulting (e.g. in the U.S.) in an associate's degree. The focus for these students needs to be on data, meta-data, coding rules, classification systems and their relationship with health informatics.
- At a second level a deeper understanding of knowledge and more advanced terminology skills, problem solving and critical thinking skills in more depth is assumed. Students at this level take e.g. a three- or four-year course of study resulting in a bachelor degree where health information management skills and knowledge is integrated with more advanced informatics knowledge and skills. Further studies may follow.

Table 3: Recommended student workload in ECTS credits for the three knowledge and skill areas of health/medical informatics course tracks inside programs of medicine and other health sciences.

Knowledge/Skill Area		**Program** Medicine, Nursing, Health Care Management, Dentistry, Pharmacy, Public Health
(1)	BMHI core knowledge and skills	40
(2)	Medicine, health and biosciences, health system organisation	5
(3)	Informatics/computer science, mathematics, biometry	15
$\sum$		60

4.3.1 Courses/Course Tracks for IT Users

Health record administration students at the mentioned first level can be regarded as IT users. The recommendations on levels of knowledge and skills are the same as for IT users mentioned in Section 4.2. Particular emphasis should be given to information literacy, health terminology, coding and classification systems, the electronic health record, and evaluation methodology. There should be introductory knowledge and skills in the knowledge/skill-domain medicine, health and biosciences, health systems organization.

4.3.2 Courses/Course Tracks for Biomedical and Health Informatics Specialists

Students of health record administration programs, respectively health information management programs, which lead to bachelor and master degrees should have the knowledge and skills of BMHI specialists, as mentioned in Section 4.2. Again, special emphasis should be given to information literacy, meta-data, health terminology, coding and classification systems, the electronic health record, and evaluation methodology and to the relationship between these concepts and the use of various informatics technologies.

Table 4: Recommended student workload in ECTS credits for the three knowledge and skill areas of a BMHI course track inside informatics/computer science programs.

Knowledge/Skill Area		Program Informatics/Computer Science
(1)	BMHI core knowledge and skills	40
(2)	Medicine, health and biosciences, health system organisation	15
(3)	Informatics/computer science, mathematics, biometry	5
$\sum$		60

4.4 Recommendations for Biomedical and Health Informatics Courses as Part of Informatics/Computer Science Programs

4.4.1 Courses/Course Tracks for Biomedical and Health Informatics Specialists

In order to achieve the levels of knowledge and skills in BMHI, recommended in Section 3 for specialists, the length of studies for educational components in BMHI should be at least 60 ECTS credits, i.e. one year of full-time studies.

In addition to the ‘core’ knowledge and skills of informatics/computer science, the relative amount of student workload for the three knowledge and skills areas inside the BMHI course track should approximately be as indicated in Table 4.

The student workload in (3) comprises knowledge and skills in biometry, semantic interoperability and evaluation methods. Applying methods and tools of informatics in health care institutions, and for concrete problems in diagnosis, therapy, nursing and health care management should be emphasized. It is essential to include ontology-based software engineering and the need to separate knowledge from system configuration, as these concepts are fundamental to achieving semantic interoperability and safe clinical decision support systems. This assists informatics or computer science students to gain more knowledge about the health care environment. Health information systems management should include the development and implementation of software and hardware components of health information systems. In medical signal and image processing technical and informatics aspects should particularly be considered.

5 Recommendations for Dedicated Educational Programs in Biomedical and Health Informatics

The aim of all dedicated programs in BMHI is to prepare graduates for careers in academic/research settings, health care facilities or organizations, governmental or international public health entities or industrial settings.

5.1 Recommendations for Bachelor Programs in Biomedical and Health Informatics

The curriculum of a program leading to a bachelor degree in BMHI should be application-related aiming to prepare students for a professional career in the field. In addition, the curriculum should offer the background and theoretical foundation necessary to pursue advanced graduate studies in this or related fields.

The objective of this undergraduate education is to equip students with specialized knowledge in the field of BMHI and the skills to apply the acquired knowledge in a variety of practical situations. The intention is to provide a deep understanding of the state-of-the-art of the discipline and the ability to translate expertise gained in the field into practical application of tools and concepts. Compared to the comprehensive formal methodological foundation of a master program, it is the practiceoriented application that predominates the undergraduate curriculum. Given the diversity of the discipline, students at the bachelor program level need to understand the breadth of the field and become familiar with the spectrum of BMHI (capturing all sub-domains such as bioinformatics, clinical informatics, public health informatics, etc.). The challenge herein is to provide knowledge and skills that students can apply in practice while recognizing that areas of interest could be explored further and in more-depth at the graduate educational level.

In order to achieve the levels of knowledge and skills recommended in Section 3, and to achieve a broad depth and breadth of all educational components, the length of study for the instructional component of a bachelor program in BMHI should be at least three years. This corresponds to a student workload of 180 ECTS credits.

For an informatics-based approach to BMHI, the relative amount of student workload for the four knowledge and skills areas for the bachelor program should be approximately as indicated in Table 5. This composition can be varied from very strong technical IT skill acquisition to less IT skill and a stronger health application focus, depending on the desired learning outcomes.

Table 5: Recommended student workload in ECTS credits for the knowledge and skill areas of a biomedical and health informatics bachelor program.

Knowledge/Skill Area		Program BMHI (bachelor)
(1)	BMHI core knowledge and skills	50
(2)	Medicine, health and biosciences, health system organisation	20
(3)	Informatics/computer science, mathematics, biometry	110
$\sum$		180

5.2 Recommendations for Master and Doctoral Programs in Biomedical and Health Informatics

For programs leading to a master or doctoral degree, it is the comprehensive formal methodological foundation for BMHI that dominates the instructional component of the program.

The objective is to provide scientific education that captures the theoretical foundations of the field, provides specialized knowledge and equips students with both practical skills and analytical approaches that will allow them to further the knowledge base of the discipline. Graduates will be able to master both the practical methods and tools and the leadership of independent research.

Unlike undergraduate bachelor programs, these graduate and post-graduate programs emphasize a formal penetration into the knowledge and foundation of the discipline and promote methodological expertise and independent analysis. Graduates are expected to contribute to the field and lead its scientific advancement.

In order to achieve the levels of knowledge and skills in BMHI as recommended in Section 3, and in order to achieve the desired broad depth and breadth of the educational components, the length of study should be at least one year full time for a master degree, corresponding to at least 60 ECTS credits. Two years of study, corresponding to 120 ECTS credits, should be preferred. Ph.D. studies or Ph.D. work should usually last three to four years.

The relative amount of study time for the three knowledge and skills areas for the master program should approximately be as indicated in Table 6.

Table 6: Recommended student workload in ECTS credits for the knowledge and skill areas of a two year (one year) biomedical and health informatics master program.

Knowledge/Skill Area		Program BMHI (master)
(1)	BMHI core knowledge and skills	80 (40)
(2)	Medicine, health and biosciences, health system organisation	20 (10)
(3)	Informatics/computer science, mathematics, biometry	20 (10)
$\sum$		180 (60)

It is expected that master students have successfully finished either a) a bachelor program in BMHI, b) a bachelor or master program in medicine, biology, public health, health administration or another health science, or c) in computer science/information science. For cases b and c additional complementary courses (for b in informatics/computer science and for c in health and biosciences, health systems) should be offered.

For programs leading to a doctoral degree, independent comprehensive research should be carried out by the student in addition to the instructional requirements already mentioned. Knowledge and skills should also have additional depth and breadth and students may choose to gain additional insight into elective fields that are at the core of their research.

6 Recommendations for Continuing Education

6.1 Continuing Education in Biomedical and Health Informatics

A certificate of 'Health Informatics', 'Medical Informatics' and/or 'Biomedical Informatics' should be offered in recognition of having acquired sufficient competence in BMHI from an academic, educational and/or practical perspective relative to specific tasks or roles within the health industry. Furthermore, for physicians, who usually have well-established forms of continuing education, there should be offered the possibility of receiving, in addition to their medical degree, the supplementary qualification of 'Health Informatics', 'Medical Informatics' and/or 'Biomedical Informatics'. This additional qualification can be issued by any national medical or health professional association or university. The same holds true for nurses, for whom various forms of continuing education are very well-established in many countries.

In order to offer courses in BMHI for continuing education, it is recommended that specific entities are established to provide such courses. These entities might be inside universities or, as academies of health/medical informatics established by any national association in BMHI or provided by an independent private entity, provided that in all cases the people responsible for course curriculum, content and educational delivery are suitably qualified (see also [89]).

6.2 Life-long Learning

Working in the field of BMHI and even using information and communication technology requires lifelong learning. Therefore opportunities for continuing education should be offered for BMHI specialists as well as IT users of the various health professions. The ability of 'learning to learn' will become of particular importance.

7 Other Recommendations

7.1 How to Commence with Biomedical and Health Informatics Education

BMHI affects all health care professionals. To commence education in this field, IMIA recommends that education in BMHI for all types of health care professionals, including the different types of specialization and levels of education, is considered. The first step is to consider the level of practice of the individual. As noted in Table 7, work in informatics depends upon whether someone has a technical/informatics or clinical background. Within informatics, one may practice more at the applied level in operational settings or may be an academic who teaches and/or performs research. For countries without formal informatics educational programs, additional steps are necessary. In this instance, teachers have to be educated ('teach the teachers') first, or, e.g., retiring BMHI faculty in developed countries could also perform this service. Next, courseware has to be prepared (or adapted) and institutes for health informatics or medical informatics must be established within universities, usually inside medical or health sciences faculties.

Table 7: Categories of informatics practice, adapted from [53].

Level of Practice	Type of Work	Example Job Titles
Academic	Individual who does research and/or teaching in an academic center	Professor; Scientist or Researcher
Applied	Individual who works in an operational informatics setting for a majority of his or her working time	Chief Information Officer; Chief Medical or Nursing; Information Officer; Project Manager; Developer; Trainer
Clinical	Clinicians and others who apply informatics in their work	Physician; Nurse; Health administrator

7.2 Modes of Education

The next consideration for informatics educational programs is (are) the mode(s) of education to be chosen, considering the specific profile and possibilities of the respective universities. Besides lectures it is of importance that practical experience within health care institutions (e.g., in hos pitals) is offered. Besides 'traditional' lectures and exercises within universities, different models of flexible, distance and supported open learning should be actively pursued. Problemoriented learning might particularly support the relevance of BMHI as it requires integration of information and a cross-disciplinary understanding [86].

7.3 Qualified Teachers

Courses and programs in BMHI must be of high quality. Teachers of courses in BMHI must have adequate and specific qualifications in this field. It must be possible to obtain such qualifications for lecturing in BMHI from universities or other institutions of higher education.

7.4 Recognized Qualifications

Education of students in BMHI, which goes beyond introductory courses in the use of information and communication technology, only makes sense if positions for these graduates exist or are created. The qualifications of such BMHI graduates must be recognized and we are recommending that health care organizations realize the need of positions as specialists in BMHI.

8 IMIA Support for Programs and Courses in Biomedical and Health Informatics

8.1 IMIA Certification

To support education of high quality in the field of BMHI, IMIA offers help by providing expert advice to persons and institutions in this field, as far as the resources of IMIA allow. This might especially be needed when commencing with educational activities and when national institutions are not yet established to do this. IMIA is also currently establishing services for the accreditation of such educational programs.

BMHI courses inside programs and specialized programs in this field can upon request add to the description of their course track or program the phrase 'endorsed by the International Medical Informatics Association' and can use the IMIA logo in this context. This is conditional to the IMIA recommendations being fulfilled and once the quality of the program, including organizational integration and resources, has been assessed by IMIA-appointed experts. Single courses cannot be considered, only course tracks or programs. The fulfilment of the recommendations and the assessment of the quality of the program will be examined by a committee usually consisting of four members of IMIA's Working Group on Health and Medical Informatics Education or other persons, experienced in BMHI education, and will be approved by the IMIA President and the Chairperson of IMIA's Working Group on education.

After approval, a written certificate, signed by the IMIA President, the Chairperson of IMIA's Working Group on Health and Medical Informatics Education, will be given to the respective organization.

Requests should be submitted to the Executive Director of IMIA.

8.2 International Programs, International Exchange of Students and Teachers

IMIA encourages and recommends international activities in educating BMHI specialists. IMIA also recommends the international exchange of students and of teachers in this field. It encourages the establishment of international programs to support this and to exchange courseware. Programs should be built up in a modular way, and international credit transfer systems such as the European Credit Transfer and Accumulation System (ECTS [85]) should be used in the respective national programs to support these international perspectives.

9 Information Exchange on Programs and Courses in Biomedical and Health Informatics Supported by IMIA

IMIA's Working Group on Health and Medical Informatics Education is a group devoted to BMHI education. Its activities include to disseminate and exchange information on BMHI programs and courses and to support BMHI courses and exchange of students and teachers. The Working Group intends to advance the knowledge of 1) how informatics is taught in the education of health care professionals around the world, 2) how in particular BMHI is taught to students of computer science/informatics, and 3) how it is taught within dedicated curricula in BMHI. Working Group members contribute to various Web-based catalogues of BMHI programs, including those mentioned in Section 1.2.

In addition, IMIA's Working Group on Health and Medical Informatics Education operates a mailing list to facilitate communication between all persons interested in BMHI education worldwide. For subscription, instructions on the Working Group's website should be followed. IMIA encourages the development and sharing of courseware of high quality for courses in BMHI. This will help to further establish courses in this field. It also encourages the use of its IMIA Working Group on education's website and list server for the dissemination of information about such courseware.

10 Concluding Remarks

These recommendations provide a framework for individual curriculum development. Individual countries may wish to develop more detailed or better defined curricula guidelines to suit their specific needs and educational system. This could include specific minimum-level competencies required for each level and knowledge/skill domain. A new professional activity needs to be officially recognized in the form of a well-established title linked to a specific salary scale. Such recognition appears to be a natural complement to a university degree. For example, in Belgium, a Ministerial Decree established in 2001 criteria for the certification of physician specialists in health data management. This official recognition by one of the member countries of the European Union opens the way to equivalence of this particular competence in all other member countries for the content of the teaching programs as well as for employment conditions [87]. Furthermore, the UK has done much work on professionalism and competencies which is published mostly as UK Council for Health Informatics Professions [88, 89]. Such national efforts are expected to influence future reviews of these guidelines.

IMIA, understanding its role as a leader in the scientific progress of the expanding field of BMHI, is also developing as part of its strategic plan [77] a knowledge base [90], which can be of real significance for educators in the field as well as to healthcare professionals.

IMIA's Working Group on Health and Medical Informatics Education may in the near future develop teaching credentialing criteria to serve as a guide for teachers wishing to participate in BMHI education.

Acknowledgements

These revised recommendations are the result of the task force team established by the IMIA Working Group on Health and Medical Informatics Education in 2006 [81]. The draft document is being communicated and discussed by the working group members during its Working Conference 2008 at Buenos Aires. The recommendations have finally been approved by the IMIA General Assembly on November 25, 2009, in Hiroshima, Japan.

Significant contributions to the recommendations came from Elske Ammenwerth (Austria), George Demiris (USA), Arie Hasman (The Netherlands), Reinhold Haux (Germany), William Hersh (USA), Evelyn Hovenga (Australia), K. C. Lun (Singapore), John Mantas (Greece), Heimar Marin (Brazil), Fernando Martin-Sanchez (Spain), Graham Wright (UK). The team would like to thank Professor Dr. Reinhold Haux, President of IMIA, for his continued support in developing the revised version of the Educational Recommendations. We also thank Dr. Peter Murray, Executive Director of IMIA, for monitoring and supporting the team's efforts.

We would like to thank all contributors of the original recommendations for their pioneering work as mentioned in [1].

The recommendations have been edited by John Mantas (co-chairman of the IMIA Working Group on Health and Medical Informatics Education) chairing the task force team.

References

[1] Recommendations of the International Medical Informatics Association (IMIA) on education in health and medical informatics. Methods Inf Med 2000; 39: 267–277. http://www.imia.org/pubdocs/rec_english.pdf. Last access: August 29, 2009.

[2] IMIA Yearbooks of Medical Informatics. http://www.imiapubs.org and http://www.schattauer.de /index.php?id=imia. Last access: August 29, 2009.

[3] Haux R, Swinkels W, Ball MJ, Knaup P, Lun KC, editors. Special Issue on health and medical informatics education: transformation of healthcare through innovative use of information technology. Proceedings of the 1997 IMIA Working Group on Education Meeting. Int J Med Inform 1998; 50: 1–300.

[4] Hersh WR, Gorman P, editors. Teach Globally, Learn Locally. Proceedings of the 2003 IMIA Working Group on Education Meeting. Int J Med Inform 2004; 73: 95–213.

[5] Mantas J, editor. Health and medical informatics education. Proceedings of the 2005 IMIA Working Group on Education Meeting. Methods Inf Med 2007; 46: 50–92.

[6] Hersh WR, Otero P, Bernaldo de Quirós FG, editors. Building Worldwide Capacity for the Health Informatics Workforce. Proceedings of the 2008 IMIA Working Group on Education Meeting. Methods Inf Med (to appear).

[7] Hasman A, Albert A, Wainwright P, Klar R, Sosa M, editors. Education and training in health informatics in Europe. Amsterdam: IOS Press; 1995.

[8] Mantas J. Health and nursing informatics education. Stud Health Technol Inform 1998; 56: 146–152.

[9] Mantas J. Future trends in health informatics – theoretical and practical. Stud Health Technol Inform 2004; 109: 114–127.

[10] Garg AX, Adhikari NK, McDonald H, Rosas- Arellano MP, Devereaux PJ, Beyene J, Sam J, Haynes RB. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA 2005; 293: 1223–1238.

[11] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, Morton SC, Shekelle PG. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med 2006; 144: 742–752.

[12] Hersh WR, Hickam DH, Severance SM, Dana TL, Pyle Krages K, Helfand M. Diagnosis, access and outcomes: Update of a systematic review of telemedicine services. J Telemed Telecare 2006; 12 Suppl 2: S3–31.

[13] Lorenzi NM. E-health strategies worldwide. In: Haux R, Kulikowski C, editors. IMIA Yearbook of Medical Informatics 2005. Stuttgart: Schattauer; 2005. pp 157–164.

[14] Hasman A, Haux R. Modeling in biomedical informatics – an exploratory analysis (part 1). Methods Inf Med 2006; 45: 638–642.

[15] Hasman A, Haux R. Modeling in biomedical informatics: an exploratory analysis (part 2). Int J Med Inform 2007; 76: 96–102.

[16] Kuhn KA, Knoll A, Mewes HW, Schwaiger M, Bode A, et al. Informatics and medicine – from mole - cules to populations. Methods Inf Med 2008; 47: 283–295

[17] Payne PR, Johnson SB, Starren JB, Tilson HH, Dowdy D. Breaking the translational barriers: the value of integrating biomedical informatics and translational research. J Investig Med 2005; 53: 192–200.

[18] Zerhouni EA. Translational research: moving discovery to practice. Clin Pharmacol Ther 2007; 81: 126–128.

[19] Baxevanis AD, Ouellette BFF. Bioinformatics: a practical guide to the analysis of genes and proteins. Third Edition. Hoboken, NJ: Wiley-Interscience; 2005.

[20] Hovenga EJS, Mantas J. Global Health Informatics Education. Amsterdam: IOS Press; 2004.

[21] Jaspers MW, Gardner RM, Gatewood LC, Haux R, Schmidt D, Wetter T. The International Partnership for Health Informatics Education: lessons learned from six years of experience. Methods Inf Med 2005; 44: 25–31.

[22] Otero P, Hersh W, et al. Translation, implementation and evaluation of a medical informatics distance learning course for Latin America. MEDINFO 2007 – Proceedings of the Twelfth World Congress on Health (Medical) Informatics. Brisbane, Australia: IOS Press; 2007. CD-ROM P421.

[23] Ball MJ, Silva JS, Bierstock S, Douglas JV, Norcio AF, Chakraborty J, Srini J. Failure to provide clinicians useful IT systems: opportunities to leapfrog current technologies. Methods Inf Med 2008; 47: 4–7.

[24] Hersh W. Health care information technology: progress and barriers. JAMA 2004; 292: 2273–2274.

[25] Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. Health Aff (Millwood) 2004; 23: 184–190.

[26] Hersh W. Who are the informaticians? What we know and should know. J Am Med Inform Assoc 2006; 13: 166–170.

[27] Hersh W. Health and biomedical informatics: opportunities and challenges for a twenty-first century profession and its education. Yearb Med Inform 2008. pp 157–164.

[28] Hersh W. A stimulus to define informatics and health information technology. BMC Med Inform Decis Mak 2009; 9: 24.

[29] Schuemie MJ, Talmon JL, Moorman PW, Kors JA. Mapping the domain of medical informatics. Methods Inf Med 2009; 48: 76–83.

[30] Roberts J. Developing health informatics as a recognised professional domain supporting clinical and health management activity. World Hosp Health Serv 2006; 42: 38–40.

[31] Joyub R. The professionalisation of health informatics in the United Kingdom. UK Health Informatics Today 2004; 42 (Spring): 1–4.

[32] Klar R. Official catalogue of subject matters in medical informatics for German medical students. In: [7], pp 145–152.

[33] Scope and Standards of Nursing Informatics Practice. Washington, DC: American Nurses Association; 2008.

[34] Detmer DE, Lumpkin JR, Williamson JJ. Defining the medical subspecialty of clinical informatics. J Am Med Inform Assoc 2009; 16: 167–168.

[35] Safran C, Shabot MM, Munger BS, Holmes JH, Steen EB, Lumpkin JR, et al. Program requirements for fellowship education in the subspecialty of clinical informatics. J Am Med Inform Assoc 2009; 16: 158–166. Erratum in: J Am Med Inform Assoc 2009; 16: 605.

[36] Leven FJ, Curriculum for medical informatics at the University of Heidelberg/School of Technology Heilbronn. Methods Inf Med 1994; 33: 262–267.

[37] Knaup P, Haag M, Leven FJ, Dickhaus H. Challenges in the evolution of the medical informatics program at Heidelberg/Heilbronn (Germany). Methods Inf Med 2009; 48: 66–75.

[38] Moehr JR. English Translation of the Minutes of the Invitational Workshop Goals, Contents and Methods for Education in Medical Informatics. Haux R, Kulikowski C, editors. IMIA Yearbook of Medical Informatics 2004. Stuttgart: Schattauer; 2004. pp 210–219.

[39] Moehr JR. The Quest for Identity of Health Informatics and for Guidance to Education in it – The German Reisensburg Conference of 1973 Revisited. Haux R, Kulikowski C, editors. IMIA Yearbook of Medical Informatics 2004. Stuttgart: Schattauer; 2004. pp 201–210.

[40] Duncan KA Austing RH, Katz S, Pengov RE, Pogue RE, Wasserman AIl. Health Computing: Curriculum for an emerging profession – report of the ACM curriculum committee on health computing education. Proceedings of the 1978 ACM Annual Conference/Annual Meeting. Washington, DC:ACM Press; 1978. pp 277–285. http://portal.acm.org/ft_gateway.cfm?id=804112&type=pdf&coll=GUIDE&dl=GUIDE &CFID=47975758&CFTOKEN=19987037. Last access: August 29, 2009.

[41] Physicians for the twenty-first century (The GPEP Report). Washington: Association of the American Medical Colleges; 1984.

[42] Haux R, Dudeck J, Gaus W, Leven FJ, Kunath H, Michaelis J et al. Recommendations of the German Association for Medical Informatics, Biometry and Epidemiology for education and training in medical informatics. Methods Inf Med 1992; 31: 60–70.

[43] Hasman A, Albert A. Education and training in health informatics: guidelines for European curricula. Int J Med Inform 1997; 45: 91–110.

[44] Council of Europe Committee of Ministers (1995): Recommendations No. R (90) 21 of the Committee of Ministers to Member States on training strategies for health information systems. In: [7], pp 3–6.

[45] Mantas J. Developing curriculum in nursing informatics in Europe. Int J Med Inform 1998; 50: 123–132.

[46] Mantas J. NIGHTINGALE – a new perspective in nursing informatics education in Europe. Stud Health Technol Inform 1998; 51: 102–113.

[47] Enabling People Programme English National Board for Nursing, Midwifery and Health Visiting. Information for caring: integrating informatics into learning programmes for nurses, midwives and health visitors. Birmingham: Institute of Health and Care Development; 1997.

[48] National Advisory Council on Nurse Education and Practice (NACNEP): A national informatics agenda for nursing education and practice. Washington DC: US Department of Health and Human Services, Division of Nursing: 1997. http://www.eric.ed.gov:80/ERICDocs/data/ericdocs2sql /content_storage_01/0000019b/80/16/d3/da.pdf. Last access: August 29, 2009.

[49] Medical School Objectives Project. Medical Informatics Objectives. Washington, DC: Association of American Medical Colleges; 1999. http://www.aamc.org/meded/msop/start.htm. Last access: August 29, 2009.

[50] Schleyer T. Competencies for Dental Informatics V 1.0. Pittsburgh, PA: University of Pittsburgh Center for Dental Informatics: 1999. http://www.dental.pitt.edu/informatics /competencies.php. Last access: August 29, 2009.

[51] Health Informatics Competency Profiles for the NHS. London: National Health Service Information Authority; 2001.

[52] Staggers N, Gassert CA, Curran C. A Delphi study to determine informatics competencies at four levels of practice. Nursing Res 2002; 51: 383–390.

[53] Covvey HD, Zitner D, Bernstein R. Pointing the way: competencies and curricula in health informatics. Waterloo, Ontario: University of Waterloo; 2001. http://www.cs.uwaterloo.ca/health_info/health_docs /CurriculaMASTERDocumentVersion1Final.zip. Last access: August 29, 2009.

[54] Mantas J Hasman A, editors. Textbook in health informatics – a nursing perspective. Amsterdam: IOS Press; 2001.

[55] O'Carroll PW; Public Health Informatics Competencies Working Group. Informatics competencies for public health professionals., Seattle, Wa:Northwest Center for Public Health Practice; 2002. http://www.nwcphp.org/docs/phi/comps/phi _print.pdf. Last access: August 29, 2009.

[56] Curran CR. Informatics competencies for nurse practitioners. AACN Clin Issues 2003; 14: 320–330.

[57] Friedman CP, Altman RB, Kohane IS, McCormick KA, Miller PL, Ozbolt JG, et al.; American College of Medical Informatics. Training the next generation of informaticians: the impact of "BISTI" and bioinformatics – a report from the American College of Medical Informatics. J Am Med Inform Assoc 2004; 11: 167–172.

[58] HIM Baccalaureate Degree Entry-Level Competencies. Chicago, IL: American Health Information Management Association; 2004. http://library.ahima.org/xpedio/groups /public/documents/ahima/bok1_025415.pdf. Last access: October 2, 2009.

[59] Garde S, Hovenga E. Australian health informatics educational framework. Brunswick East, Australia: Australian College of Health Informatics; 2006. http://www.achi.org.au/sites /default/files/Health_Informatics_Educational_Framework _20060326.pdf. Last access: October 2, 2009.

[60] Ivanitskaya L, O'Boyle I, Casey AM. Health information literacy and competencies of information age students: results from the interactive online Research Readiness Self-Assessment (RRSA). J Med Internet Res 2006; 8: e6.

[61] VISION 2016: A Blueprint for quality education in health information management. Chicago, Il: American Health Information Management Association (AHIMA); 2007. http://www.ahima.org/emerging_issues /Vision2016BlueprintforEduc.pdf. Last access: August 29, 2009.

[62] Health informatics professional core competencies. Toronto, Ontario: Canadian Health Informatics Association (COACH); 2007. https://secure.coachorg.com/opendoc.asp?docID=1062 Last access: August 29, 2009.

[63] Health information science knowledge and skills. Chicago, IL: Medical Library Association; 2007. http://www.mlanet.org/education/platform/skills.html. Last access: August 29, 2009.

[64] Pigott K, de Lusignan S, Rapley A, Robinson J, Pritchard-Copley A. An informatics benchmarking statement. Methods Inf Med 2007; 46: 394–398.

[65] Huang Q. Competencies for graduate curricula in health, medical and biomedical informatics: a framework. Health Informatics Journal 2007; 13: 89–103.

[66] Joint Workforce Task Force. Health information management and informatics core competencies for individuals working with electronic health records. Chicago, IL, and Bethesda, MD: American Health Information Management Association and American Medical Informatics Association: 2008. http://www.ahima.org/infocenter/whitepapers/workforce_2008.pdf. Last access: August 29, 2009.

[67] Gassert C. Technology and informatics competencies. Nursing Clinics of North America 2008: 43: 507–521.

[68] Karras BT, Davies J, Koo D; Working Group on Competencies for Public Health Informatics Competencies. Competencies for public health informaticians, Public Health Informatics Competencies. 2007, Seattle, WA: Center for Public Health Informatics; 2008. http://cphi.washington. edu/competencies. Last access: August 29, 2009.

[69] Gardner RM, Overhage JM, Steen EB, Munger BS, Holmes JH, Williamson JJ, et al.; AMIA Board of Directors. Core content for the subspecialty of clinical informatics. J Am Med Inform Assoc 2009; 16: 153–157.

[70] Hersh W. AMIA-OHSU 10×10 Program – Logistics, Accessing Demo, Detailed Curriculum, Learning Objectives, and Additional Information. Portland, OR, Oregon Health Science University, 2009. http://www.billhersh.info/10x10.html. Last access: November 25, 2009.

[71] Gugerty B, Delaney C. TIGER Informatics Competencies Collaborative (TICC) Final Report, Technology Informatics Guiding Educational Reform (TIGER) Initiative, 2009. http://tigercompetencies.pbworks.com/f/TICC_Final.pdf. Last access: November 25, 2009.

[72] HIT Workforce Competencies by Role. Washington, DC, Office of the National Coordinator for Health IT, 2009. http://healthit.hhs.gov/portal/server.pt?open=18&objID=888534&parentname=CommunityPage&parentid=15&mode=2&in_hi_userid=11113&cached=true. Last access: November 25, 2009.

[73] http://www.hiww.org/. Last access: August 29, 2009.

[74] http://www.amia.org/informatics/acad%2526training/index.asp. Last access: August 29, 2009.

[75] http://www.amia.org/informatics/acad%2526training/international.asp. Last access: August 29, 2009.

[76] http://www.imia.org. Last access: August 29, 2009.

[77] The IMIA strategic plan: towards IMIA 2015. http://www.imia.org/images/IMIA_Strategic_Plan.pdf. Last access: August 29, 2009.

[78] Lorenzi NM. Towards IMIA 2015 – the IMIA strategic plan. Yearb Med Inform 2007. pp 1–5.

[79] Murray P, et al. Let a thousand flowers bloom: transition towards implementation of the IMIA strategic plan. Methods Inf Med 2007; 46: 625–628.

[80] Murray PJ. The IMIA strategic plan – towards IMIA 2015. Yearb Med Inform 2008. pp 7–15.

[81] Minutes of the IMIA General Assembly, August 2007, Brisbane, Australia. Report of the Vice-President for Working Groups.

[82] Knaup P, Dickhaus H. Perspectives of medical informatics: advancing health care requires interdisciplinarity and interoperability. Methods Inf Med 2009; 48: 1–3.

[83] Kulikowski CA. The micro-macro spectrum of medical informatics challenges: from molecular medicine to transforming health care in a globalizing society. Methods Inf Med 2002; 41: 20–24.

[84] van Bemmel JH. Medical informatics is interdisciplinary avant la lettre. Methods Inf Med 2008; 47: 318–321.

[85] European Credit Transfer and Accumulation System: http://ec.europa.eu/education/lifelonglearning-policy/doc48_en.htm. Last access: August 29, 2009

[86] Hasman A, Boshuizen HP. Medical informatics and problem-based learning. Methods Inf Med 2001; 40: 78–82.

[87] Moniteur Belge du 13 12 2001: Arreté Ministériel du 15 octobre 2001 fixant les criteres d'agrément des médecins spécialistes en gestion de données de santé N 2001–3555; C-2001/22760; pp 43044–43046.

[88] Roberts J. Developing the Health Informatics Professional. In: Hayes, G, Barnett D, editors. UK Health Computing: Recollections and reflections. BCS, May 2008.

[89] UK Council for Health Informatics Professions, http://www.ukchip.org. Last access: November 25, 2009.

[90] Wright G, et al. IMIA knowledge base. Report submitted to IMIA, June 2008.

E-Health Resources in the Graduate and Postgraduate Medical Education in Hungary

Presented in part at the EFMI Special Topic Conference (14-15 April 2011 , Laško, Slovenia)

Ferenc Bari[1], **Erzsébet Forczek**[1], **Zoltán Hantos**[1]

[1]Department of Medical Physics and Informatics, Faculty of Medicine, University of Szeged, Hungary

Abstract

Although biomedical informatics lacks a clear and theoretically-grounded definition, there is a general consensus on its involvement in the training of health professionals. Since medical education is fully packed with traditional disciplines (anatomy, physiology, surgery, etc.) and also with new, challenging subjects like molecular biology or genetics, it is very difficult to find an appropriate slice of time in the curriculum for the proper training of medical informatics. Although there are accepted recommendations by professional organizations (e.g.: International Medical Informatics Association [IMIA]) on what makes up an informatics curriculum, medical schools teach what they consider important, what can be financed and what can be fit into the tight time frame. In this paper, we describe the most important factors influencing medical informatics education in general, in Hungary and at our faculty in particular.

Our department is responsible for teaching medical informatics for students in medicine, dentistry, pharmacy and nursing. In addition, we provide courses for post-graduate students in various PhD programs focusing on specific aspects of info-communication involved in all phases of research. We summarize our teaching experience over the past ten years and explain how we teach biomedical informatics to different groups of health professionals. We call attention to the need for defined basic skills and knowledge in informatics at each level of the health care education. We emphasize that even with limited resources, it is possible to create and maintain valuable training programs especially with effective trans-border cooperation.

Keywords

medical curriculum, biomedical informatics, e-health, graduate and post-graduate studies, trans-border cooperation

Correspondence to:

Ferenc Bari
Department of Medical Physics and Informatics,
Faculty of Medicine, University of Szeged,
Address: 6720 Szeged, Korányi fasor 9, Hungary
E–mail: bari.ferenc@med.u-szeged.hu
Tel/Fax: (36) (62) 545–077

EJBI 2011; 7(2):19–24
recieved: June 20, 2011
accepted: November 21, 2011
published: December 23, 2011

1 Introduction

Although there are obvious variations among specialties, physicians spend 25-30% of their time on administrative tasks that require the use of computers and other information technology devices. Nowadays, with universal accessibility, internet databases are considered a major avenue in making medical knowledge available to almost all medical professionals. The booming field of medical informatics and e-Health assists physicians and healthcare specialists in diagnosis, follow-up, and treatment of patients through electronic means over wide geographic distances. The use of e-Health approaches and systems in the healthcare sector is becoming a daily practice, as almost all medical practitioners increasingly use computers to store patients' data, assist the patient, and make decisions via support systems and databases, etc. Accurate diagnosis, better treatment solutions and patient relationships are increasingly within reach when using e-Health facilities. It has been accepted widely that the use of medical informatics creates a hub for medical database management, and contributes greatly to the evolution of diagnostic and treatment technologies. As a result, a lot may be expected of medical informatics with respect to promoting improvement of health conditions throughout the world, both by contributing to the quality and efficacy of health care, and accomplishing research in the fields of innovative biomedical as well as computer, health, and information sciences.

In 2003, the Institute of Medicine's Health Professions Education Summit identified the utilization of informatics as one of the five domains of core competency for health care professionals [1]. Additionally, informatics also underpins the other four competency domains, which are to provide patient centered care, to work in interdisciplinary teams, to employ evidence-based practice, and to apply quality improvement [1].

It is also important to point out that, in a draft level survey of The Tuning Project for Medicine [2] the Use of information and information technology effectively in a medical context was ranked 10 among the 12 highest Competences/Learning Outcomes (N.B. preceding Apply scientific principles, method and knowledge to medical practice and research). In view of the statements above, it is essential to address

- the current situation of medical informatics training in Hungary,
- its conformity with international standards, recommendations and trends and
- the potential of establishing cross-border co-operations in the development of advanced curricula in the training of medical and other health science professionals.

According to E-Health indicators, nearly all Hungarian doctors use a computer at their offices; however, permanent internet access and the use of professional web sites are still limited and personal web presentation is below the European average.

Although medical professionals and institutions emphasize the need of the continuing medical education (CME) for maintaining and improving knowledge, skills, competence and performance, unlike in several countries [3], there is no existing national CME program that covers certain specific fields such as medical informatics. With the overall growth of informatics, the medical education system should also provide programs at both graduate and post-graduate levels. While there is a wide consensus as to the importance of this urgent need, several factors hamper the construction and operation of a CME system in medical informatics. In particular:

1. lack of involvement of health informatics in the core curriculum of most medical schools,
2. limited human and instrumental resources of educational institutions, including medical and nursing schools,
3. competence and skill level are not well defined and measured,
4. there are no comprehensive education programs currently available.

2 Methods and Results

We have collected relevant information from the 4 Hungarian faculties of medicine (Budapest, Debrecen, Pécs and Szeged), from the most active partner universities in Romania (Timisoara and Cluj) and the University of Vienna, Austria. We have been teaching medical informatics for more than 15 years and collected information from colleagues, former and present students, etc. We have made a critical review of the contents of the courses taught.

The four Hungarian medical schools have differing educational strategies and programs for medical informatics.

When we compare the formal description of curricula, we can conclude that in most faculties the medical informatics is taught early on in the medical studies. In Hungary, medical studies are divided into 4 parts (semesters 1-4: basis sciences, semesters 5-6: pre-clinical studies, semesters 7-10: clinical studies and semesters 11-12: clinical rotation). As Table 1 indicates, medical informatics is taught explicitly in 3 of the 4 schools. In all places informatics-related subjects are elective (in the table "C" can be misleading because it indicates that the subject is still elective but "strongly recommended"). In other words, 80% of the Hungarian medical students would currently be able to fulfill the curricular criteria without taking a course in medical (or any) informatics. In fact, it has been indicated that 50-80% of the students attending the medical schools do take courses in informatics. The inhomogeneous course structure summarized in Table 1 also indicates that while there is a tendency to create an independent course for medical/bioinformatics it is far from general. Additionally, although biostatistics (elementary statistics) is a mandatory subject in the curriculum, in most medical faculties, biostatistics has not been separated from medical informatics.

Effective use of medical information systems requires harmonized educational programs in medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and informatics/computer science. Because of the diverse structure of the graduate and postgraduate education, it is almost impossible to establish dedicated complementary programs [4, 5]. At the University of Szeged, our department is responsible for the teaching of medical informatics for students in medicine, dentistry, pharmacy and nursing. It has always been a complex task to create profession-specific education programs that are also cohesive with one another [6, 7]. There is an agreement that all curricula should include some common components (basic concepts and common software available for higher education in Hungary) but there is an ongoing debate on what kind of additional specific tools and resources should be involved.

Table 1: Components of medical informatics curricula at Hungarian universities (C: Compulsory Subjects; C/E: Compulsory Elective Subjects; E: Elective Subjects; O: Optional).

Faculty of Medicine	Course	Semester	Credit	Hrs/week (Theory)	Hrs/week (Practice)	C; C/E; O
Debrecen	Medical Informatics	1-2	3	0	2	C/E
	Biostatistics	1	2	1	1	C
Budapest	Biostatistics and Informatics	1	3	1.5	2	C
	Biostatistics II.	7-10	2	1	1	C/E
	Medical Informatics	7-10	1	1	0	C/E
Szeged	Informatics	2	3	1	2	C/E
	Biostatistics	1	1+2	1	2	C C/E
	Medical Informatics I. II.	8-10	2/2	1/1	1/1	C/E
	Biostatistics II. III.	8-10	2/2	1/1	1/1	C/E
Pécs	Biostatistics	1	2	1	1	C
	Informatics: I.-II.-III.	8-10	1/1/2	0.5/0.5/1	0.5/0.5/1	C/E O
	Informatics of Medical Literature	8-10	2	0	2	O

Our approach is very practical: with close cooperation with faculty members of the schools of dentistry, pharmacy and nursing, and via the specialization of our teaching staff we try to define the profession-specific targets. Specifically, nurses have commonly been regarded to possess poor IT skills (and are not motivated for the introduction of IT); it has also been observed that nurses are more frequently reluctant to use computers than other healthcare staff groups, and have made more statements against curriculum development in all disciplines. We must make it clear for them that computers will not disappear from health care; on the contrary, their increasing use is unequivocally predicted. Changing the attitude of nurses is a particular challenge for our department.

A further question is the phase of medical training in which medical informatics should be introduced [8]. At the Faculty of Medicine of the University of Szeged, medical informatics is taught in the second semester of the first academic year, as an elective subject. Currently, about 85-90% of the students choose this course. The lectures (1 hr/week for 14-15 weeks) cover the basic concepts of informatics, its development, the fundamentals of computer architecture, principles and functions of operating systems and computer networks. Special emphasis is given to the creation of electronic documents, the characteristics of textual, tabular, graphic and other components of documents and their unification. The lectures deal with the possibilities inherent in the Internet, the properties of databases and data warehouses, and the most significant medical, biological and bibliographic databases available. The aim of the practical course (2hr/week in small groups -less than 16 students in each) is to provide the students with a basic practical knowledge in electronic communication and evaluation of biomedical data, and with the tools and knowledge to create electronic documents.

Even if medical informatics modules obtain some limited niche, they must be adapted to the rigid, weekly-based, formal and traditional lecture–practice structures. Innovations such as intensive, course block structures, in which students learn about problem-driven medical informatics as a component of diagnosis are very rare. Such structural changes in the educational system disturb the traditional composition of a semester and may generate undesired, contradicting opinions and tension among professors of other disciplines. Additionally, even with the implementation of programs proposed above, very limited skills can be taught within a short period of a week or so. It is important to recognize medical informatics as a tool and a skill. Any skill is learned and imprinted most efficiently when the education is problem-driven and put into the context of the environment it is to be used within.

For these reasons, we have to be aware of the demands of other departments and the specific electronic teaching material they offer when we assemble the material of our medical informatics course. Developing a wide knowledge about the nature of medical information and how it may be obtained from the internet also prompts the departments of medical informatics to develop their general curriculum accordingly. For students who are interested in extra-curricular research activity there are elective courses in the 4th-5th years dealing with specific problems such as biomedical signal acquisition and processing, or advanced statistics. The use of statistical packages assumes a basic knowledge in calculus and applied statistics but the proper use also requires advanced knowledge in informatics. In order to correspond with the more practical period of medical training, some studies suggest that medical informatics courses should be integrated into the later, more hands on, portion of the education (7th-10th semester) [8]. On one hand it is a good idea to have training later on in the program because the technology discipline changes very quickly and skills learned in the 1st year may not still be current in the sixth year, on the other hand informatics knowledge could improve the basic medical studies from the very beginning. Therefore we made a compromise, there is a course in the second semester and there is additional make-up or advanced courses offered later on the studies.

Even with advanced human, methodological and technical background we have to face to several problems and answer important questions.

What are the major motivations that could attract medical students to take up medical informatics as an elective subject? How can these students transform informatics knowledge and computer skills gained during the module into skills that aid in learning fundamental medical subjects such as anatomy, physiology, surgery or general medicine more effectively?

As our department teaches medical physics and statistics, we have the unique opportunity to communicate with students from the very beginning of their university careers to point out the usefulness of informatics. Our teaching material is available on internet (www3.dmi.u-szeged.hu); records of laboratory practices are documented on intelligent platform, and the calculations in statistics seminars are also computer-based. Therefore we can convince the students that they would benefit a lot by choosing “medical informatics” as an elective course.

Mandatory courses in informatics and statistics are an essential part of postgraduate university education programs in Hungary. At our faculty, informatics and statistics are taught in two semesters (30 and 45 hrs, respectively). In contrast to undergraduate courses that concentrate on basic skills and everyday medical practice, PhD courses focus on specific aspects of info-communication involved in all phases of research: the efficient use of scientific databases, data organization, processing and presentation. An important feature of these courses is that medical PhD programs involve a substantial number of non-MD participants, such as biologists, pharmacists, chemists, physicists, etc.; this necessarily broadens the scope of the training.

Apart from the proper establishment of a medical informatics module, it would be very useful for medical students if they are provided with a detailed picture on the specific information infrastructure available at their medical school (mailing system, security, e-library, administrative supports like patient registration, etc.), upon their admission. This introduction might also increase the familiarity of medical students with information technology and electronic facilities at the medical school. At the same time, this may not necessarily be the task of the medical informatics departments exclusively, but could preferably be a joint effort among various departments.

3 Discussion

3.1 Human Resources

With the advent of computing science, computational resources gradually became available in the environment of university medical faculties, teaching hospitals, etc. University computing centres, running mainframes and providing computational service in the 1970’s and 1980’s, were particularly helpful for clinical and medical research teams that needed help in various areas, such as signal processing, data organisation and analysis, database building and mathematical modelling; as well, the staff of these Hungarian university computer centres were often involved in graduate and postgradual teaching at the university. This symbiotic and interactive environment for the developers and the users of the medical informatics systems was very fertile in formulating new concepts and procedures, and it more than offset the limitations inherent in the computing facilities of that decades. During the last twenty years many parts of the former system became independent from the universities. Software development, network maintenance and other special tasks were formed into their own spin-off companies that offer services to medical schools. Therefore, research and development became independent and was no longer deeply embedded into the university environment. Today, we unfortunately experience a gradually increasing distance and a phase lag between the information created by the industrial solution providers and what is available to medical teams seeking solutions for their specific informatics problems in medical research, practice and education. In addition, if research is not done within the academic environment there are no financial resources to cover the costs of conferences and workshops to increases learning and knowledge. Co-operation of all the parties involved in the phases of the problem identification, idea formulation, development of tools and their testing is badly needed.

The increasing need for better and more comprehensive training in informatics is strongly limited by several factors including teachers. The most crucial point is how to recruit and maintain staff for teaching medical (health) informatics. Since there is a general shortage of well-trained experts, medical schools have to compete for teachers with informatics companies, which offer far higher salaries and better career opportunities. Consequently, it is almost impossible to offer such income or/and promotion opportunities that would attract young professionals to join informatics departments.

Medical informatics should not be solely the subject of specific courses or specific departments. It should be a general approach throughout an entire training program. Therefore, it seems desirable that education professionals undergo special training to learn new teaching methods and utilization of educational aids including information technology, newer media, interactive learning, group education and individualized teaching. There are obvious questions to be answered: who trains the trainers, who sponsors such trainings and how could it fit into the program of a faculty? Since countries like Hungary have a small number of teachers on the field of biomedical-health informatics we welcome the initiative by the IMIA of establishing international exchange programs for students and teachers [9].

3.2 Structural Barriers

There are many reasons why medical schools are reluctant to incorporate medical informatics in their core curriculum. First of all, medical school professors do not all fully recognize the importance and meaning of medical informatics. Secondly, the densely packed medical school curriculum does not leave a suitable time slice for the proper training of medical informatics [10].

Lack of involvement of health informatics in core curriculum in most medical schools creates artificial barriers in medical education and slows down information transfer. The lack of formal health informatics training begs the questions as to whether future doctors will understand the full capabilities of electronic platforms and technologies, and whether they will know how to evaluate them and integrate them into their practices.

A recent paper by Stead et al. [11] discusses the major directions and tasks needed for better e-Health education. The authors emphasize that medical schools should have academic units in biomedical informatics in order to achieve a sufficient knowledge for education and research. Only this can ensure that clinical information systems are fully integrated with and support the education and research missions of the medical school. In addition, medical educators should also be sufficiently trained to model clinical and research IT applications, in order to modernize curricula appropriately, and evaluate trainees and teaching methods [3].

3.3 Standards and Development

The question asked many years ago, "To what degree are medical schools teaching medical informatics and how?" has still only partially been answered. Medical Informatics is a constantly developing field. Some years ago, topics like literature searching, internet use, computer assisted diagnosis, hospital information systems and electronic patient records constituted the maximum requirement for a medical graduate. Today telemedicine, telediagnosis, and patient-support systems also require more and more attention in a curriculum.

Although there are very good standards (they should be updated year by year) on what makes up an informatics curriculum [9], medical schools teach what they consider important, what can be financed and what can be forced into the tight time-frame [8].

Despite the European legislative framework requiring mutual recognition of medical degrees and qualifications, little has been done to examine the comparability and standards of such qualifications or to describe them in detail. Responsibility for deciding what should be learned during that time and what the outcomes of that learning should be is devolved to individual medical schools.

The challenges faced by medicine today are enormous. Setting and continuously updating curricula are an ongoing task of all medical schools [6, 9, 12]. Our experience indicates that recommendations by the IMIA are extremely useful in curriculum development but these recommendations usually do not reach the appropriate persons with decision competences. Medicine has always welcomed new technology; therefore informatics was incorporated into everyday medical practice decades ago. In fact, the development of many fields in informatics was driven by the demands of health care and occasionally stimulated by the medical educational system.

3.4 The System Should be Output Driven

Although it is desirable for all kinds of medical professionals to graduate with a certain set of computer and information management skills, there are no general computer skill assessment systems which allow national or international comparisons and evaluation of such skill-sets. It is imperative to define the basic skills and knowledge requirements for various health care professionals [5]. It would be a challenging, but worthwhile, project to construct an international evaluation system which would be accepted by the various faculties teaching health sciences. Development of an ongoing training program for employees including the educational staff is a task closely related to the graduate and postgraduate courses organized for students.

The lack of formal health informatics training begs the questions as to whether future doctors will understand the full capabilities of electronic platforms and technologies, and whether they will know to evaluate and integrate them into their practices. Several studies indicate that, although to differing degrees, training problems in E-Health affect almost all countries [3, 9, 10, 13, 14]. Establishing informal and formal professional networks would help in constructing and updating curricula, and setting acceptable competence and skill levels. Therefore, there is an urgent need for harmonized national and international programs for better education of the health professionals.

3.5 Cross-Border Projects May Help in Finding Additional Resources

Common cross-border projects combining the efforts on specific issues should aim at finding salary supplements and facilitating common research-development activity. When we consider effective cross-border collaborations in education programs of our discipline, it is worth mentioning that the terms medical informatics and biomedical informatics have diverse definitions in distinct geographical regions and even within the same country [12]. Therefore intensive discussions and careful exploration of the various definitions/descriptions in the neighbouring areas would help in reaching consensus and in finding common terminology [7]. The artificial political, cultural and economical separation during the second half of the previous century also has forced Hungary to find individual solutions for problems in medical informatics training, as well as all other fields of health care [14]. When globalization incorporated our countries into Western culture, countries of the former Eastern block had no choice but to follow international trends, by taking on widely accepted operation systems, adapting basic documentation methods and implementing Western-type education systems. Even though adaptation became a universal routine, the presence of various backgrounds and former goals resulted in information systems in the former socialist countries becoming disparate and confusing [13]. Now, the necessity of more intensive regional dialogues and cooperation urges experts in biomedical informatics to engage in more intensive collaboration, in order to establish joint concepts and practice for improving the health conditions of our countries [9, 15, 16]. Consequently, we have to voice our individual problems, and analyze them in order to find common solutions. It has been emphasized several times that human resources are critical in determining the level of performance of the health care delivery and for the attainment of national health goals in all countries.

4 Conclusions

In summary, an efficient development of partnerships within the health care system assumes that all professionals involved must possess strong informatics and interpersonal knowledge, and skills reaching beyond their own individual fields. There is an emerging need to define the basic skills and knowledge for each level of the health care education. A wide range of collaboration including trans-border cooperation offers a unique opportunity for the establishment of common criteria for basic skills and knowledge, via joint discussions, collaborative thinking and concerted action.

Acknowledgements

Supported by Hungarian Scientific Research Funds (OTKA K81266) and by ETT.

References

[1] Greiner, A. C., & Knebel, E. (Eds.). Health Professions Education: A Bridge to Quality, Institute of Medicine of the National Academies Washington: The National Academies Press, 2003.

[2] Cumming, A., Ross M. The Tuning Project for Medicine–learning outcomes for undergraduate medical education in Europe, Medical Teacher, 2007; 29, 636-641.

[3] Lungeanu D, Tractenberg RE, Bersan OS, Mihalas GI. Towards the integration of medical informatics education for clinicians into the medical curriculum. Stud Health Technol Inform. 2009;150:936-40.

[4] Shanahan MC. Transforming information search and evaluation practices of undergraduate students. Int J Med Inform. 2008; 77:518-26

[5] Wu JH, Chen YC, Greenes RA. Healthcare technology management competency and its impacts on IT-healthcare partnerships development. Int J Med Inform. 2009; 78:71-82

[6] Zvárová J. Education in biomedical informatics and eHealth. Stud Health Technol Inform. 2008;134:27-32.

[7] Zvárová J. On the medical informatics structure. Int J Med Inform. 1997;44:75-81.

[8] Kern J. Medical informatics in the medical curriculum–when? Stud Health Technol Inform. 1999;68:484-8.

[9] Mantas J, Ammenwerth E, Demiris G, Hasman A, Haux R, Hersh W, Hovenga E, Lun KC, Marin H, Martin-Sanchez F, Wright G. IMIA Recommendations on Education Task Force. Recommendations of the International Medical Informatics Association(IMIA) on Education in Biomedical and Health Informatics. First Revision. Methods Inf Med. 2010 Jan 7;49:105-120.

[10] Strauss S. Canadian medical schools slow to integrate health informatics into curriculum CMAJ 2010; 182:E551-2

[11] Stead, W. W, Searle, J. R., Fessler, H. E., Smith, J W., Shortliffe, E. H. Biomedical Informatics: Changing What Physicians Need to Know and How They Learn, Academic Medicine, 2011; 86:429-434.

[12] Haux R. Aims and tasks of medical informatics. Int J Med Inform. 1997 44:9-20

[13] Duplaga M. E-health development policies in new member states in Central Europe. World Hosp Health Serv. 2007; 43:34-8

[14] Balogh N. The role of XML in medical informatics in Hungary. Stud Health Technol Inform. 2002; 90:168-73

[15] Jaspers MW, Gardner RM, Gatewood LC, Haux R, Evans RS. An international summer school on health informatics: a collaborative effort of the Amsterdam Medical Informatics Program and IPhiE–the International Partnership for Health Informatics Education. Int J Med Inform. 2007; 76:538-46.

[16] Jaspers MW, Gardner RM, Gatewood LC, Haux R, Schmidt D, Wetter T. The International Partnership for Health Informatics Education: lessons learned from six years of experience. Methods Inf Med. 2005; 44:25-31

Teaching Medical Informatics to Medical Students – What are the Challenges in a Model Curriculum?

Behrends M.[1], **von Jan U.**[1], **Paulmann V.**[2], **Matthies H. K.**[1]

[1]Peter L. Reichertz Institute for Medical Informatics, Hannover Medical School, Germany

[2]Dean's office, Hannover Medical School, Germany

Abstract

One of the aims of medical education is teaching the students not only theoretical knowledge but also to equip them with the necessary practical skills. In Germany, a revision of the federal law on medical education in 2002 had exactly this aim. In the following years, all around Germany, medical programs tried to reflect this change in paradigm and in 2005, a new model of teaching medicine was introduced at the Hannover Medical School. The topic of medical informatics was integrated in the third year of the model curriculum. Although medical informatics itself plays an important role in medical care, it soon became apparent that the opinion of students does not reflect this importance, rather, they do not really understand why they have to deal with this subject at all or they are under various misconceptions concerning the role of medical informatics in medicine.

Apparently, the conventional ways that had been in use in the past to teach medical informatics to medical students left too many questions unanswered. To alleviate this situation, we utilized the feedback given by the students – gathered in evaluations, but also voiced in live discussions as well as anonymous forums – to improve the way medical informatics is taught. In this paper, we first present a short appraisal of the situation, backed by the information gathered from the students, and then move on to give a more detailed view on the methods used to better convey the benefits of medical informatics in our classes. The new approach of teaching is also evaluated using standardized methods and the results are presented.

Keywords

medical education, medical informatics, evaluation, curriculum, learning objectives

Correspondence to:

Marianne Behrends
Hannover Medical School
Peter L. Reichertz Institute for Medical Informatics
Address: Carl-Neuberg-Str. 1, 30625 Hannover, Germany
E–mail: behrends.marianne@mh-hannover.de

EJBI 2011; 7(2):25–30
recieved: June 6, 2011
accepted: September 30, 2011
published: December 23, 2011

1 Introduction

A common aim of medical education is educating students to become practically skilled, scientifically educated and (self-) reflecting physicians. In Germany, the federal law on medical education was revised in 2002 to meet this aim more appropriately. In many medical faculties, more emphasis was placed on the development of practical abilities and a better integration of preclinical and clinical aspects into new course concepts was started. In 2005, a new model curriculum was introduced at Hannover Medical School (MHH) [1].

The principle of HannibaL (=Hannover integrated adaptive practice-related learning concept) is a patient-centered, integrated training based on profound scientific knowledge. Although this approach may work well for clinical subjects, the real challenge for education in medical informatics is to emphasize its practical relevance in modern medicine.

In HannibaL, the medical informatics classes are integrated into a module of three weeks duration during the third year of studies. The students receive 23 hours of lectures and tutorials in medical informatics. Other non-clinical subjects taught in this module include epidemiology and biometry.

All modules provided for human medicine are regularly evaluated by the central evaluation unit of the Hannover Medical School. The evaluation of the module for medical informatics received in the past made it apparent that a new approach concerning the didactical design and the contents was necessary. In the following paragraphs, we will describe the methods we employed for restructuring the module during the study year of 2008/09.

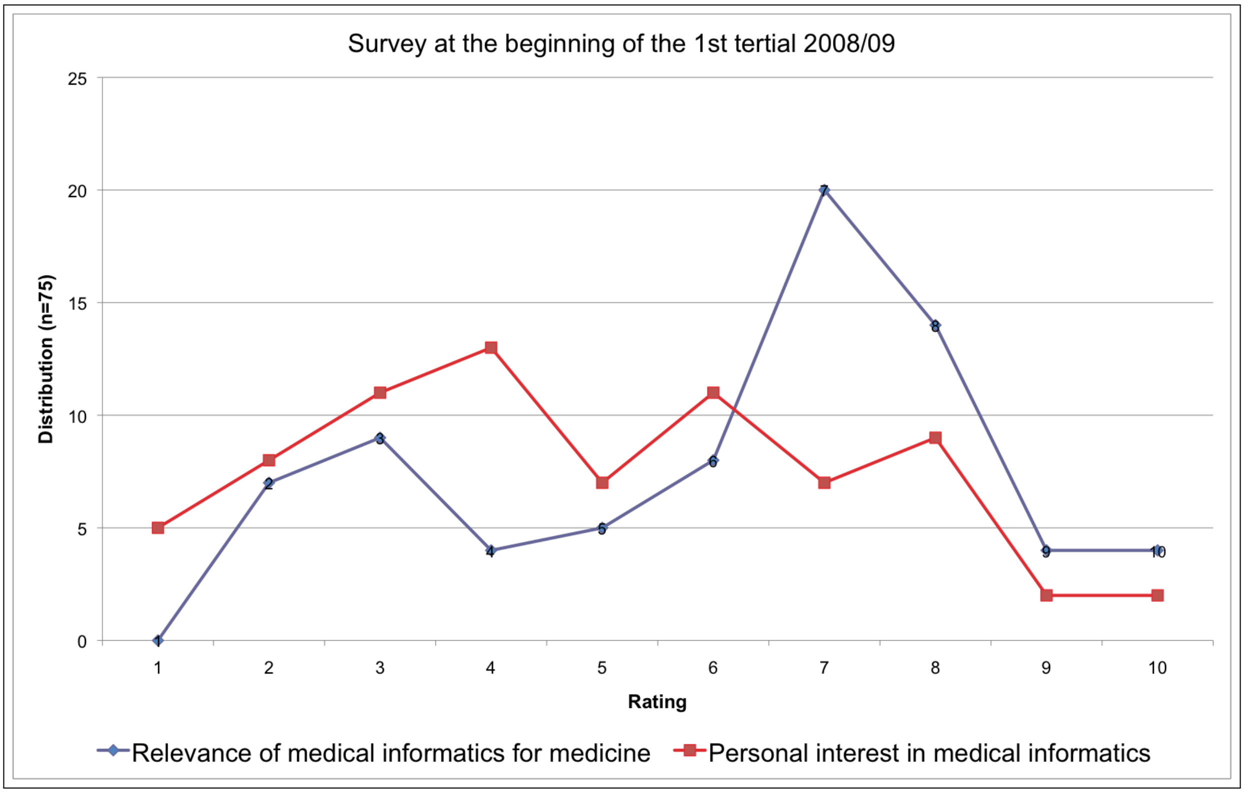

Figure 1: Survey at the beginning of the 1st tertial 2008/2009, n= 75.

2 Background

In the Hannover model curriculum each academic year is subdivided into three parts, so called tertials [2]. Thus, the same lessons have to be given three times each academic year to groups consisting of about 90 students. Our course covers the basics of medical informatics, i.e. clinical decision support systems, medical information systems, healthcare telematics, data privacy protection, health technologies, medical image processing and biosignal analysis as well as general aspects of using the internet in medicine.

At the MHH, all courses are evaluated after the corresponding final exam using a consistent scheme [3]. In addition to a summative grade, students evaluate in single categories teachers, content, learning material, organisation, exam and patient orientation of the course. Thus, the evaluation is also performed three times a year. A positive evaluation is not only of personal interest for the lecturers. It is also of importance concerning the acquisition of additional, internal funding from the university that is being distributed depending on the respective evaluation.

The evaluation of the module for medical informatics left much to be desired. Thus, it was necessary to reconsider the underlying concept and the orientation of the medical informatics course. Our starting hypothesis was that medical students are mostly unaware of the importance of medical informatics within modern medicine. They only consider the course as an unpopular obligation with little or no relevance for their future profession.

Since patient orientation is one of the central points in HannibaL, starting in the academic year of 2008/09, a fictitious patient was introduced as a leading figure into all topics taught in the medical informatics classes, with the goal of better showing the significance of medical informatics in the various phases of patient care. This patient and how the methods of medical informatics facilitate the storage and evaluation of the various data acquisitioned during his stay in a hospital became the central educational concept of our classes. For each of the basic topics in medical informatics, we tried to give practical examples for our virtual patient to make clear that medical informatics plays an important role in the whole process of patient care. Nevertheless, while it was not hard to provide practical examples concerning our "virtual patient" (who suffered from a shoulder dislocation) when talking about imaging modalities and image processing, in some cases, such as clinical decision support systems, it was hard to establish a relationship between the described case and the sub-specialty of medical informatics. Thus, our method of implementing a more patient oriented way of teaching did not always proceed smoothly.

By asking the students to complete further questionnaires in addition to the standard evaluations, we tried to get detailed information about the factors playing a role concerning the dislike many students harbour concerning the subject of medical informatics.

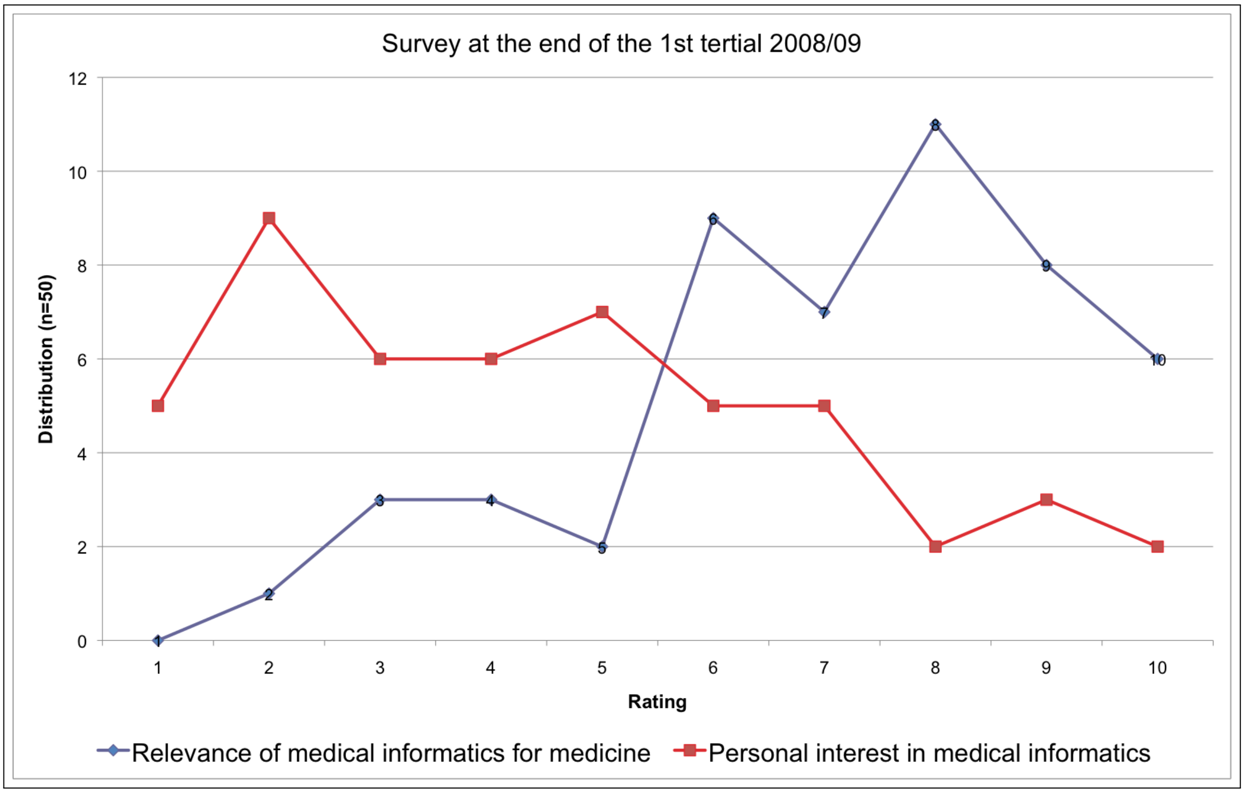

Figure 2: Survey at the end of the 1st tertial 2008/2009, n=50.

3 Methods

At the beginning and the end of each medical informatics course, the students were asked to complete a questionnaire that asked about the perceived importance of medical informatics within medicine as well as their personal interest in the topic of medical informatics.

Furthermore, in each tertial, four seminars with 20-25 participants each took place, where the role of medical informatics within medicine was discussed critically. For this purpose, an anonymous forum within ILIAS, the learning management system of the MHH, was used. During the seminar, the students were first asked to anonymously answer the questions. Afterwards, the various opinions expressed during the anonymous phase were jointly discussed. In each following tertial, we refined the questionnaire using insights of the previous cohorts.

In the following sections, based on the results of the standardized evaluations as well as our additional evaluations, we will describe the overall assessment of the medical students concerning medical informatics and the consequences we drew based on the results. This is mainly done based on the results of the 1st tertial.

Unfortunately, the response rate for the additional surveys at the end of the 2nd and 3rd tertial was not high enough to be able drawing significant conclusions from them.

4 Results

4.1 Students' Perspectives on Medical Informatics

The results of the first survey in the 1st tertial of the academic year of 2008/2009 showed that there is a considerable mismatch between the estimation of the importance of medical informatics and the students' personal interest in medical informatics.

With a scale of 1 representing "irrelevant" to 10 representing "very relevant", the students were supposed to rate the perceived relevance of medical informatics within medicine. Again using a scale from 1 to 10, the students also had to indicate their personal interest in medical informatics with 1 representing "no interest" to 10 representing "high interest".

The mean of the importance of medical informatics is 6 pts. (sd=2.3), whereas the mean of the estimated personal interest was only 5 pts. (sd=2.4). The difference is best illustrated by a graphical illustration of the respective dispersion of all values (fig. 1). The importance curve is skewed left, the interest curve is slightly skewed right and has a flat kurtosis.

The survey at the end of the 1st tertial shows that the opinion of the students did not change for the better (fig. 2). In contrast, students' interest was even lower with a mean of 5 pts. (sd=2.5). The evaluation of the importance of medical informatics improved only slightly

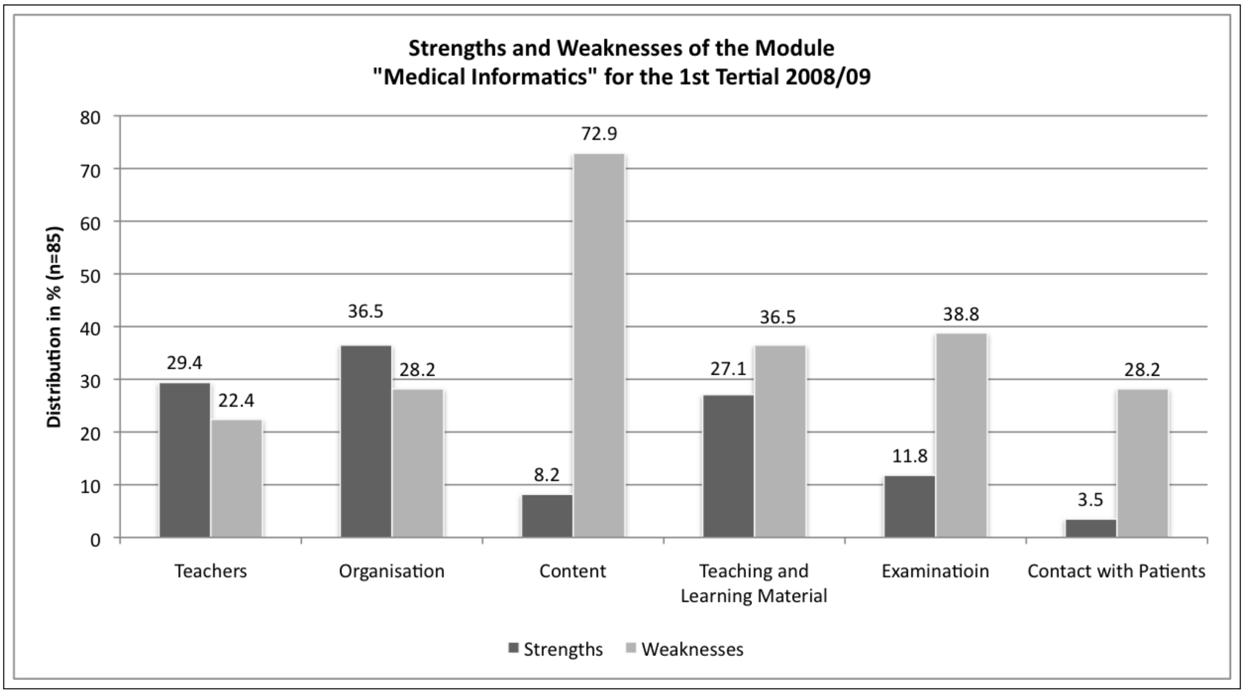

Figure 3: Standard evaluation 1st tertial 2008/2009.

(7 pts./sd=2.3). 50 students (50%) filled in the questionnaire.

To gain a better insight into why students think medical informatics is important for medicine but not important for themselves as medical students, we started a more detailed analysis of the entries given in the anonymous forum as well as of the comments the students voiced during the seminars.

4.2 Results from Discussing the Matter with the Students

Already in the 1st tertial, during the aforementioned discussions in the critical reflection part of the medical informatics seminar, it became apparent that many of the students are hardly interested in dealing with the principles and various issues of medical informatics. We collected their arguments for or against the integration of the subject into the medical curriculum.

Typical statements were: “Why do I have to learn all this now, the software will certainly have changed when I am finished”, “Why do I have to learn so many details, in practice all problems will be solved by experts anyway” or “Why do I have to learn things now that do not really help me in my current situation”.

Even though the students generally recognized medical informatics as relevant for medicine, they were not enthusiastic about its integration into the medical curriculum. We wanted to determine why and therefore adapted the questions posed to the students in the 2nd tertial. Now, the students were also asked what skills in medical informatics they deem important for a physician.

It turned out that many medical students have a very narrow perspective: they hold the opinion that with regard to skills in medical informatics, physicians only have to be able to correctly operate the software necessary for medical care. Since software and its handling changes over time, for the majority of the students it does not make sense to already have to learn about current software in their 3rd year of studies since it will be years until they really have to work with the software; they also think that the software will look and work completely different until then.

We were surprised by these statements, since the goal of our classes in medical informatics was not to train the students in operating certain software products. Whenever a program was shown during the lectures or used during the seminars, it was only mentioned as an example to show basic principles. The focus rested on the general principles and methods of medical informatics. Apparently there was a discrepancy between the view of the teacher and the view of the students regarding the learning objectives of the class.

4.3 From Patient Orientation to Personal Learning Objectives

Our attempt to receive better evaluation scores through integrating a fictitious patient to underline the relevance of medical informatics for patient care did not serve to increase the personal interest of the students in

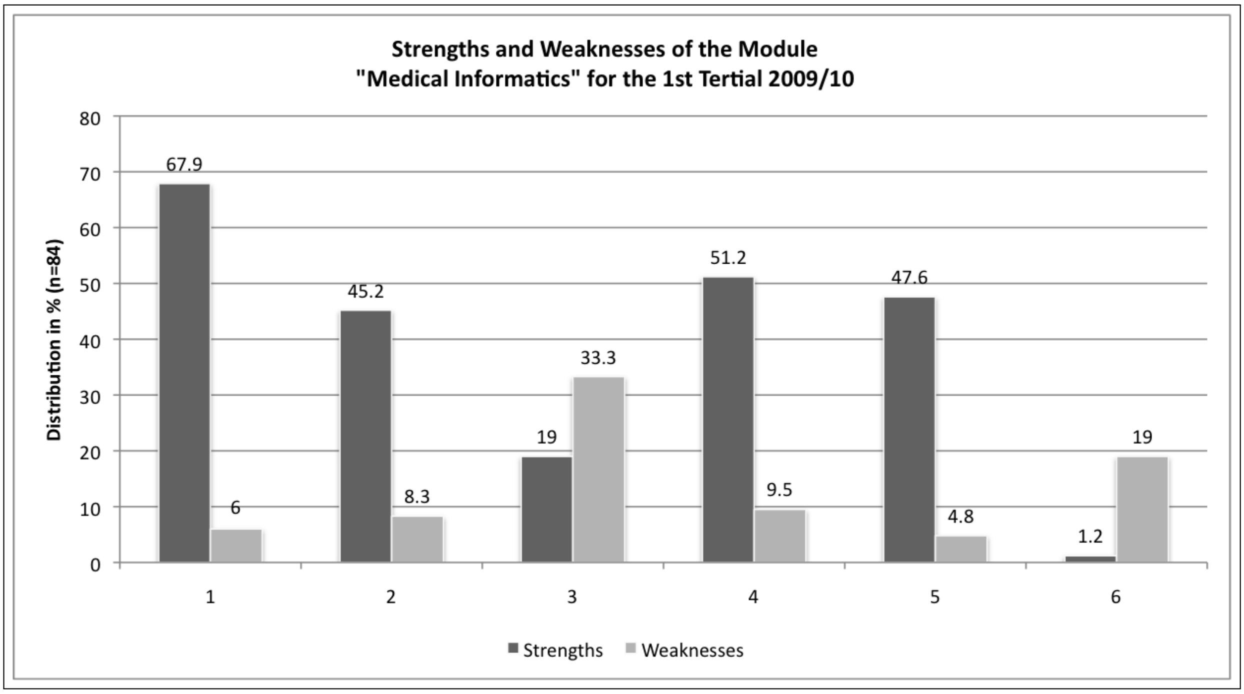

Figure 4: Standard evaluation for the 1st tertial of 2009/2010.

the subject. The course did not manage to alter student's points of view. Results of the standard evaluation for the same cohort documented the dissatisfaction (fig. 3). The students are supposed to evaluate the quality of the teaching staff, the content of the classes, the provided materials, the patient contact and the final exam as well as the organizational aspects. In addition, there is an overall evaluation of each module using the grading system also employed by German high schools that is based on 15 points representing exceptional results and 0 points representing a failing grade.

Despite our efforts to put an emphasis on showing the importance of medical informatics in medicine, at the end of the 1st tertial, the overall assessment still left much to be desired with 6 points. Of the participating students, 79.9% rated the contents of the module as a weakness of the module. Only the lecturers as well as the organizational aspects of the module received positive evaluations.

The sobering results of the evaluation as well as the statements the students made during the critical reflection seminars made us once again rethink our didactical concept. A new concept was worked out. Therefore, each lecturer reflected the students' perspectives based on the analysis of their accounts.

Thus, the educational concept of our medical informatics course was revised and learning objectives for each subtopic were defined. The learning objectives were supposed to give the students a binding concept of the competencies they were expected to acquire and how these skills already could be helpful in their present training. In this way, the students were shown the practical relevance of the presented lectures. The goal was to give them a distinct idea about the impact and importance of medical informatics in all phases of medical education. Therefore, at the beginning of the tertial, a comprehensive introduction to the course was given. Each topic was presented by one of the lecturers. During this introduction, each lecturer gave a personal account of what he or she expected the students to learn, including some basic examples to pique the personal interest of the students. Thus, the various topics of medical informatics became tangible – something the students could better understand and apply.

It turned out that the new concepts of the class and especially the presentation of the learning objectives lead to a significant increase in the standard evaluation results in the next study year (fig. 4). Apart from the assessment of the learning contents themselves and the integration of patients in the syllabus, the other evaluated aspects were all seen as strengths of the module. Also, the overall assessment rose to 10 points and was thus much better than in the previous tertial.

The trend of the standard evaluation in 2009/10 was continued subsequently. Currently the results level off around 9 points. In the opinion of the students, the strong points of the module continue to be the lecturers, the organizational aspects, the learning materials as well as the written exam.

5 Conclusions

In publications about the skills medical students are supposed to acquire in medical informatics, there is a focus on various topics of epidemiology and biometrics and even within the medical informatics community; "pure" medical informatics is not really seen as an interesting topic [4, 5, 6, 7]. In addition to the scientific perspective on medical informatics, we put the emphasis on a competency-based approach as described by Manta et al. [8]. Aside from describing the learning outcomes, it also seems important to implement the learning objectives as individual learning goals for the students. Of course, clearly defined learning objectives are important in all educational settings. Nevertheless, a clear definition of the learning goals becomes even more important when considering the education in medical informatics. The description of the learning objectives at the beginning of the course was one of the factors leading to better evaluation results.

Still, the evaluations and the discussions in the seminar showed that some students did not at all fathom why they had to gain deeper insights into medical informatics. They acknowledge that the topic contributes essentially to the medical field. Yet, it seems to be a domain that is reserved to experts from outside who provide their knowledge to physicians and hospitals. Related to their education, many students reduce medical informatics to the proper use of software. It is therefore important to broaden this perspective.

Starting in the academic year of 2009/10, the evaluation results finally became satisfactory, although the exceptional evaluation results of the 1st tertial deteriorated a bit in the following tertial and finally levelled off at an average of 9 points. One of the remaining problems is that since attendance is during the lectures is not mandatory, many students refrain from participating. One of the main contributing factors is probably the time demands that are placed on the students. Medical informatics still remains a seemingly superfluous subject to many students. To firmly establish medical informatics as an important part of medical studies, it would be helpful to better integrate its various aspects with clinical subjects: methods of digital image processing could be combined with radiology, the functions of clinical information systems could be explained as soon as the students start the clinical part of their education and diagnosis supporting systems might better be introduced while the students are taught diagnostic methods.

References

[1] Paulmann, V. Fischer, V., Haller, H.: Hannibal: the new model curriculum in Human Medicine at Hannover Medical School (MHH). Annual Meeting of the Association for Medical Education in Europe (AMEE) September 2008, Prague, Czech Republic. http://www.amee.org/documents/AMEE%202008%20Final%20Abstract%20Book.pdf

[2] http://www.mh-hannover.de/10123.html

[3] Paulmann, V., Seibicke, N., Fischer, V.: The role of exams in the new Model Curriculum in Human Medicine at Hannover Medical School (MHH) - Assessing quality and the quality of assessment. Research in Medical Education - Chances and Challenges 2009. Heidelberg, 20.-22.05.2009. http://www.egms.de/static/de/meetings/rme2009/09rme24.shtml

[4] Stang A., Hense H.W., Jöckel K.H.: Epidemiologie, medizinische Biometrie und medizinische Informatik (Q1) - klinische Relevanz des Lehrstoffs näher bringen - aber wie?, GMS Me Inform Biom Epidemiol. 2005; 1(3): Doc 19

[5] Pritsch M., Wetter T., Becher H.: Konzept und Rahmenbedingungen des Querschnittsbereiches "Epidemiologie, Medizinische Biometrie und Medizinische Informatik" (Q1) im Rahmen des Reformcurriculums HeiCuMed. http://www.egms.de/en/meetings/gmds2005/05gmds515.shtml

[6] Forster J.: Möglichkeiten des Kompetenzerwerbs in Epidemiologie, Medizinischer Biometrie und medizinischer Informatik. http://www.egms.de/en/meetings/gmds2005/05gmds520.shtml

[7] Hilgers R.D., Feldmann U., Jöckel K.H., Klar R., Rienhoff O., Schäfer H., Selbmann H.K., Wichmann H.E.: Empfehlungen zur Umsetzung der Approbationsordnung für Ärzte vom 27.06.2002 in den Fächern Epidemiologie, Medizinische Biometrie und Medizinische Informatik; GMS Med Inform Biom Epidemiol 2005; 1(1):Doc05 (20050407)

[8] Mantas J et al. Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision. Methods Inf Med. 2010 Jan 7;49(2):105-120

Design of an Innovative Double Degree Graduate Program in Health Informatics and Nursing: Bridging Nursing and Health Informatics Competencies

Elizabeth Borycki[1,2], **Noreen Frisch**[2], **Marjorie McIntyre**[2], **Andre Kushniruk**[1]

[1]School of Health Information Science, University of Victoria, Victoria, Canada

[2]School of Nursing, University of Victoria, Victoria, Canada

Abstract

This article describes a novel double-degree Master's program in Nursing and Health Informatics. The program was designed to prepare nurses with graduate level competencies in both nursing and health informatics. Such competencies are essential for professionals working in the rapidly expanding fields of nursing and health informatics. There is an immediate and longer-term need for clinical professionals with such expertise in Canada. Furthermore, a program was needed to provide graduate level credentialing in nursing and health informatics so graduate students could develop needed workplace competencies at the intersection of nursing and health informatics in the international move towards electronic health records. The double-degree program described in this paper is the first of its kind. The design, underlying rationale, and initial experiences with the program are described in detail in this paper.

Keywords

nursing informatics, health informatics, biomedical informatics, medical informatics, nursing informatics education, nursing education, health informatics education, competencies, curricula

Correspondence to:

Elizabeth Borycki
School of Health Information Science
University of Victoria
Address: Victoria, British Columbia, Canada V8W 3P5
E–mail: emb@uvic.ca

EJBI 2011; 7(2):31–39
recieved: June 20, 2011
accepted: November 1, 2011
published: December 23, 2011

1 Introduction

There is an increasing need for well qualified health informatics specialists who possess clinical skills as well as health informatics knowledge, skills and judgment. Indeed, in many efforts to deploy complex health information systems (HISs) throughout the world, it has been reported that a major stumbling block has been a lack of professionals who understand the complexities of HISs (such as electronic health records - EHRs) and the healthcare settings where they are deployed.

To address these issues, the Schools of Health Information Science and Nursing at the University of Victoria collaborated to design a Masters program that allows students to graduate with two degrees – one in health informatics and one in nursing. The Masters program is designed to bridge competencies in the two domains. The School of Health Information Science is an educational organization which has offered degree programs in health informatics for thirty years and is recognized for its teaching, research and consultancy in health informatics [1]. The School of Nursing at the University of Victoria is recognized for its innovative delivery of education, in particular distance models for delivery of programs.

This paper describes the design of a new double-degree program in Nursing and Health Informatics. It begins with a discussion of the background to the program's development followed by related graduate programs. This discussion is followed by the description of the health and human resource issues that have influenced this program's development, along with a description of the program curriculum and course structure. The paper concludes with an overview of the experiences to date and lessons learned in the program's implementation.

2 Background to Bridging Nursing and Health Informatics Education

Over that last twenty years we have seen a considerable rise in the implementation and use of health information systems (HISs) and information and communication technologies (ICTs) in healthcare globally. Many countries are currently implementing HISs and ICTs in an effort to streamline healthcare delivery, reduce medical errors and improve the overall quality and efficiency of healthcare services (e.g. United States, countries of the European Union and Canada) [2, 3, 4, 5]. In Canada, Canada Health Infoway [6] has been working with federal, provincial and territorial governments to implement HISs that would lead to a pan-Canadian EHR, or repository of electronically-maintained information about a patient's health status and healthcare that can be used by patients and healthcare professionals involved in their care [5, 6, 7]. Such a large scale deployment of HISs and ICTs is not possible without a substantive, formally educated workforce in the discipline of health informatics [5, 8, 31].

In Canada, health informatics is considered to be the field that deals with information processing (including computers) and communication in healthcare practice, disease prevention, education and research [8]. This includes not only access to health related information electronically by healthcare workers, but also by the general public and patients (e.g. use of Web-based health information resources to access health information) [7]. The sub-fields of health informatics include bioinformatics, imaging informatics, public health informatics, educational informatics and clinical informatics (of which nursing and medical informatics are a part) [5, 9].

Health informatics professionals are responsible for designing, developing, implementing, evaluating, and maintaining HISs in a wide array of healthcare settings [7, 8, 9]. According to Canada's Health Informatics Association (COACH), health informatics professionals must have information, clinical and management science competencies to be successful in the field of health informatics [8]. Many of these competencies overlap with those outlined by the International Medical Informatics Association's (IMIA) work on education in biomedical and health informatics [9]. These competencies also take into account the local, Canadian historical developments in the fields of health informatics and nursing education and are reflective of the regional health authority, government and industry sectors that employ health informatics professionals [8].

2.1 Defining Health and Nursing Informatics in Canada

Historically, health informatics has been an interdisciplinary field—drawing researchers and professionals from differing domains of practice (e.g. computer science, medicine, nursing, management, library science). Health informatics professionals drew on knowledge and research from these fields to inform their practice. Over the last twenty years, health informatics has emerged as a separate discipline developing its own body of knowledge that is contributing to its own growth as a discipline as well as contributing knowledge back to the disciplines from which it originated (e.g. computer science, medical science, nursing science and library science) [5, 8]. As a consequence, health informatics professionals in Canada require information, clinical, and management science competencies. Health informatics professionals need these core competencies to have the knowledge, skills and judgment to effectively implement and maintain HISs [8].

The Canadian Nursing Informatics Association [10] draws on the work of Staggers and Bagley-Thompson's [11] in defining nursing informatics in Canada. They identify that:

> "nursing science, computer science, and information science are used to manage and communicate data, information, and knowledge in nursing practice. Nursing informatics facilitates the integration of data, information, and knowledge to support clients, nurses, and other providers in their decision-making in all roles and settings." [11].

In summary, nursing informatics can be considered a discipline-specific form of informatics practice within health informatics. Nursing informatics borrows from nursing science, computer science, information science and nursing practice to support nurses, other healthcare providers and patients (including information structures and processes).

2.2 Related Graduate Programs

Internationally, a number of biomedical, health and nursing informatics programs have been developed and implemented in varying countries around the world. In the area of nursing informatics, there are a number of nursing schools that offer students a Masters in nursing with a specialization in nursing informatics; for example, the University of Maryland [12] and the University of Utah [13]. Efforts in nursing informatics in Europe have included projects such as NIGHTINGALE which have focused on implementing strategy for training nurses to apply and use HISs [14]. In the area of biomedical informatics, there have been a wide range of programs emanating from medical and computer science/informatics schools. For example, in North America there are masters programs in biomedical informatics such as those offered by Columbia University [18], Arizona State University [15], Oregon Health and Science University [16] and Washington State University [17]. In Europe there have been several pioneering medical, biomedical and health informatics Masters programs, a number of them predating those in North America such as the Medical Informatics Program at Heidelberg/Heilbronn in Germany that was founded in the 70's [33]. Other health and biomedical informatics programs can be found in the Netherlands [19, 20], Austria [21], Spain [22] and other European countries [23, 29]. Extensions of this work has included the EuroMISE project which involved 20 universities, research institutions and companies and created a teaching network of higher education institutions focusing on medical informatics, medical statistics and epidemiology [24]. Programs designated as health informatics masters have also appeared worldwide, including those in Saudi Arabia [25], Peru [26] and Canada [7]. Many of these health informatics programs have focused on competencies and have been influenced by curricula recommendations released by IMIA [14].

Despite the number of health and biomedical informatics related programs, in reviewing the published literature describing innovations in graduate education in the area, we were unable to find any programs that provide students with a Masters of Nursing (MN) and a Masters Science (MSc) in Health Informatics upon completion. At the University of Victoria, we have observed a demand for trained professionals that have competencies in both nursing and health informatics (as described in the next section on Health and Human Resource Issues). Furthermore, the University of Victoria, having both a School of Health Information Science and Nursing, allowed for the opportunity to explore the creation and implementation of a new type of program that was designed to integrate training, leading to the full list of competencies at the graduate level for nursing and health informatics. Given the current world-wide landscape regarding related programs and the observed Canadian workforce needed to develop graduates with dual competencies (as described in the next section) we embarked on the creation of the new double degree program described in this paper.

2.3 Health and Human Resource Issues

In Canada the need for skilled health informatics professionals is significant [31]. According to statistics published in 2008, only 2.4% of Canadian hospitals have a full electronic patient record [32]. 97.6% of hospitals [32] use both paper and electronic records (i.e. hybrid environments) to record patient information [26, 27]. As well, up to 60% of physicians still use paper patient records in their offices. The Canadian government recently funded Canada Health Infoway, the organization that has spearheaded the use of EHRs, another 500 million dollars (after an initial billion dollar investment) to continue its work in the area of EHR implementation [6].

Canadian estimates indicate there is a shortage of qualified health informatics professionals [8]. A published report identified that there is a need for 8,490 health informatics professionals over the next 5 years with an additional 32,170 individuals who are working in the health informatics field requiring skill broadening to include the health informatics competencies necessary to work in the area as outlined by COACH [8, 31].

In terms of nursing, at the time the current program was being developed there were no Masters of Nursing programs that prepared graduates with a specialization in nursing informatics in Canada. There were only a few post-graduate certificate programs and standalone courses [8, 10]. Therefore, even if the existing health informatics programs attempted to increase their student output, there would still be a severe shortage of health informatics professionals well into the future [8, 28, 29, 30, 31].

The program described in this paper grew out of a response to current and future needs for health informatics professionals in Canada. More specifically, there is a need for health informatics professionals that can support current implementation and future use of EHRs. It is anticipated that healthcare records in all major institutions (i.e. hospitals, home care agencies, clinics and physician offices) will become paperless. Canada's insitutions are moving away from hybrid (paper-electronic EHRs) to full EHRs [27]. These EHRs require updating to reflect advances in clinical practice, administrative work and technological advances. EHRs necessitate a major shift in healthcare practice and the need to develop experts to support that practice. As a consequence, the objective of the new program is to prepare graduates to be at the forefront of health informatics in Canada and internationally.

A double-degree program was designed because individuals experienced in healthcare practice, medical/nursing terminologies and institutional culture who are also experts in computerized technologies are needed to guide other health professionals in these new practice demands [8, 31, 34]. Professional nurses are in a unique position to become leaders in this field once they obtain the necessary foundational knowledge and familiarity with advanced or graduate level nursing and health informatics practice. Currently, there are many nurses nationwide who are implementing EHRs. There are also many nurses who are members of the Canadian Nursing Informatics Association. The majority of nurses working in nursing/health informatics roles hold bachelor's degrees in nursing. Some hold graduate degrees that are clinically or administratively focused (i.e. focusing on clinical aspects of nursing or health services administration/policy). These individuals were the initial target audience for this program – the program would provide them with opportunities to broaden and/or develop graduate level nursing and health informatics competencies.

The infrastructure for the double degree program already existed in the Faculty of Human and Social Development at the University of Victoria. The School of Nursing has offered the Masters of Nursing (MN) degree, with a current enrolment of nearly 200 students. The School of Health Information Science has offered a Master of Science (MSc) in Health Informatics since 1990, with a current enrolment of approximately 90 students. While MN programs are offered at many universities throughout the country, the School of Health Information Science at the University of Victoria is the only School in Canada devoted to health informatics and offers the only distance MSc in Health Informatics in Canada. The University of Victoria had a unique opportunity to offer a double-degree program in these areas as there is expertise in both domains that is not readily available in any other location in Canada.

3 Aims, Goals, and Objectives of the Double-Degree Program

3.1 Distinctive Characteristics

The double-degree program was designed to offer baccalaureate-prepared nurses the opportunity to develop advanced practice competencies in two fields, creating an exciting career pathway. The program was designed so that an MN and MSc in Health Informatics could be completed in three years, where two separate degrees would take four years.

Further, the double-degree program is designed to provide the opportunity to engage in two distinct but related fields simultaneously and in an integrated manner. To complete the program, students take both degrees concurrently. In addition, the program was designed to be offered online through distance and distributed learning technologies (using Moodle® and Blackboard Collaborate®). The intent was to make the program accessible to students throughout Canada and beyond.

Typically, a new program requires substantial resources for program development and implementation. However, this double-degree program took advantage of existing programs, existing courses, and resources already available to MN and MSc Health Informatics students. In addition, this new program was complementary to the university's current programs as it provided interdisciplinary opportunities not only to the students in the double-degree program but to all graduate and undergraduate nursing and health informatics students, though elective courses, seminars, research collaborations, and other forms of scholarship.

3.2 Program Goals

The goal of the double-degree program is to prepare advanced practice nurses for careers at the intersection of nursing and health informatics, thus the overarching goal is to produce graduates who are qualified to work in a wide range of roles, including consulting roles, analyst positions, management roles (i.e. directors and chief information officers) and specialists in clinical informatics across Canada and abroad.

The faculty developing and delivering the program believe that nurses possessing the requisite health informatics background will be particularly sought after for key leadership roles in promoting and disseminating HISs. The program also prepares students to pursue further doctoral work in either nursing or health informatics.

Currently, there are many nurses who are members of the Canadian Nursing Informatics Association and who are already working in health informatics. Many nurses have expressed a desire to advance their knowledge and skills at the intersection of nursing and health informatics (and this number is rapidly growing). In fact, currently there are many more health informatics professional work opportunities than health informatics positions in Canada and abroad). These positions are in regional health authorities, hospitals, HIS vendors, consulting companies, federal and provincial governments and health information organizations (e.g. Canadian Institute for Health Information). There is a major demand for appropriately trained graduates to design and implement EHRs and this demand is continuing to increase.

4 Curriculum Design

The double-degree curriculum follows the curriculum design of each degree (i.e. the Masters of Nursing and the Masters in Health Information Science). Each student entering the program must be a Registered Nurse with a Bachelor of Science in Nursing degree and (generally) with at least two years of clinical practice experience to enter the program. The admission requirements are the same as for the individual nursing and health informatics programs (i.e. students must fulfill the requirements for entering a Masters in Nursing, as well as the requirements for entering a Masters in Health Information Science program) with the addition of a pre-requisite undergraduate-level statistics course for students. Applicants are also expected to have obtained at least two years of relevant work experience before applying (e.g. working as a intensive care nurse or a community health nurse) and complete a research thesis.

Each student takes advanced Nursing courses and a series of courses in Health Informatics. The Nursing courses taken are the nursing graduate core classes in philosophy, theory and methodology, plus a course on issues and two electives. The health informatics courses to be taken are those in HIS, an overview of health informatics, database design, and research, plus two electives supporting students' career goals. The course sequence is a three-year program designed for full-time students. Each year requires coursework in both disciplines. Table 1 lists the curriculum sequence for the double-degree program.

In addition each student completes two experiential learning or cooperative (Coop) education experiences that give them work experience in one placement that is specifically nursing/clinical informatics related and another placement in a more general health informatics setting. The cooperative education experiences are planned within the existing structure of the School of Health Information Science. Students are expected to develop health informatics competencies and to also demonstrate the ability to apply advanced nursing concepts to practice.

A research based thesis is required. Students enroll in a thesis seminar class at the end of the 2nd year of the program and will have one calendar year in which to develop and execute the thesis project. The supervisory committee consists of two faculty co-supervising students, one from each discipline (nursing and health informatics). The faculty supervisor from health informatics provides expertise from his or her field of research and work (e.g. human factors in healthcare, organizational behavior and change management, patient safety). The faculty supervisor from nursing provides expertise from a clinical and advanced nursing practice perspective. As the supervisors have regular contacts with their students each term in these two programs, the integration of the disciplines is evaluated as the student progresses.

4.1 Schedule of Course Delivery

It should be noted that the reason that coursework in both disciplines is required in each year is that the student is expected to simultaneously apply the concepts/theories and competencies from each discipline to the other throughout the double degree program (see Table 1). Students taking a nursing theory class are directed to apply the theory to the practice of health informatics. Likewise students taking a health information systems course will be directed and guided to reflect on information systems in the practice of nursing.

A total of 2 Nursing electives and 2 Health Informatics electives are required.

Electives are chosen in consultation with student's supervisors from nursing and health informatics (see below).

Health Informatics electives:

HINF 561	Project Management
HINF 551	Electronic Health Record
HINF 511	Clinical Decision Support Systems
HINF 560	Health Care Quality Improvement
HINF 573	Applied Biostatistics
HINF 575	Human Factors in Healthcare
HINF 510	Information Management and Technology
HINF 562	Procurement in Health Informatics
HINF 591	Ethical and Legal Aspects of Health Informatics (Special Topics)

Nursing electives:

NURS 503	Qualitative Approaches to Research in Nursing
NURS 504	Phenomenology and Hermeneutics Approaches to Inquiry
NURS 514	Nursing Ethics for Leadership and Practice
NUNP 531	Applied Pathophysiology
NUNP 532	Pharmacology Interventions in Health and Illness
NUNP 540/541	Advanced Assessment and Diagnostic Reasoning
NUED 570	Engaging with Pedagogy: Teaching and Learning in Nursing Education

4.2 Delivery Methods

The program begins with an onsite initial orientation to the nursing and health informatics programs. In the School of Health Information Science this consists of a half-day non-credit orientation to the School, its resources, the library, the educational tools used in the program, the faculty, an overview of the health informatics courses is provided and thesis requirements. The Nursing orientation is a general, three-day orientation for all students in the distributed MN program. It is non-credit, and the only time students are required to be on campus for the duration of their program. The orientation includes an introduction to the graduate nursing program, time to meet with faculty advisers, an introduction to MN core courses and an introduction to online learning tools.

All courses are delivered through online distance learning technologies (e.g. Blackboard Collaborate®, Moodle®), supplemented with an orientation to each of the three years. The experiential or cooperative learning experiences are in locations throughout Canada. Each experiential or cooperative education experience will be 455 hours in length. (Note: all courses are currently taught online and both School's faculty are experienced with this delivery method).

4.3 Learning Outcomes, the Curriculum Design and Competencies

4.3.1 Master of Nursing Degree

The learning outcomes for the Master of Nursing program have been documented in the establishment and the delivery of the Master of Nursing degree. The program goals for the Master of Nursing program are that the graduates:

1. Develop advanced knowledge in nursing complemented by knowledge from other sciences and bodies of knowledge.

2. Develop in-depth knowledge related to a particular area, context of population of practice.

3. Be critically-reflective practitioners.

4. Develop a focused vision of advanced nursing practice.

5. Provide leadership and direct care in advanced practice roles.

Table 1: Master of Nursing (MN) and Master of Science (MSc) in Health Informatics Double-degree [Full time (3+ years)] (NURS = nursing course; HINF = health informatics course; NUHI = nursing and health informatics).

Year 1		
September-December	**January-April**	**May-August**
NURS 506 Philosophical Knowledge & Advanced Practice Nursing	NURS 507 Theoretical Knowledge & Advanced Practice Nursing	NURS 508 Methodological Knowledge & Advanced Practice Nursing
HINF 572 Health Informatics: An Overview	HINF 550 Health Information Systems Design	Coop or Experiential Nursing Experience
	HINF 501 Database Design	
Year 2		
September-December	**January-April**	**May-August**
HINF 503 Research Methods in Health Informatics	Coop or Experiential Nursing Experience	NURS 565-566-567 Trends and Issues in Advanced Practice Nursing
HINF Elective		NURS Elective
HINF Elective		NURS 593 or HINF 580 Thesis/Project Seminar
Year 3		
September-December	**January-April**	
NURS Elective	NUHI 599 Thesis [until completion]	
NUHI 599 Thesis		

6. Contribute to knowledge development.

7. Develop and support "best practices".

8. Negotiate and manage change.

Table 2 illustrates the other learning outcomes and the courses/activities/content that supports the student in achieving the expected nursing outcomes. Courses that support each of the learning goals stated are illustrated in Table 2.

4.3.2 Masters of Science in Health Informatics Degree.

The learning outcomes for the Masters of Health Informatics degree are consistent and reflective of the expected competencies for the field as outlined by the health informatics professional organizations in Canada and IMIA [8, 9]. More specifically, the students are expected to develop advanced competencies in the following areas of health informatics:

1. the health sciences,

2. the information sciences,

3. the management sciences,

4. research.

For double degree students (i.e. health informatics component) the focus could be on one of a number of areas of practice in health informatics (see Table 3 sections - health science, information science and management science competencies in health informatics). Table 3 provides learning goals and the courses/Coops/thesis that support students achieving the expected health informatics outcomes.

5 Current Status and Experiences to Date

Developed over a two year period (i.e. 2008-2009), the Masters of Nursing and Health Informatics Program received approval from the British Columbia Ministry of Education in 2010. The program's first intake was in the Fall of that year. The initial pilot intake consisted of five students. In the Fall of 2011, nine more students were admitted to the program for a current total of 14 students. In the Fall of 2011, the Schools received approximately 30 applications to the double degree program.

The program is growing rapidly and is of interest to nurses pursuing graduate studies. The program has attracted nurses from across Canada who have an interest in pursuing graduate studies in both nursing and health informatics. The double degree students have integrated well with traditional nursing graduate students (when taking graduate level nursing courses) and

Table 2: Nursing Learning Goals and Courses.

Learning Goal	Course
Advanced knowledge	NURS 506 Philosophical Knowledge & A.P. Nursing NURS 507 Theoretical Knowledge & A.P. Nursing
Critical reflection in practice	NURS 506 Philosophical Knowledge & A.P. Nursing Nursing Coop
Vision of advanced nursing practice	NURS 507 Theoretical Knowledge & A.P. Nursing
Leadership and direct care	Nursing Coop
Knowledge development	NURS 508 Methodological Knowledge & Advanced Practice Nursing Thesis
"Best practices"	NURS 508 Methodological Knowledge & Advanced Practice Nursing NURS 565 Nursing Issues
Negotiate/ manage change	Nursing Coop NURS 565 Nursing Issues

Table 3: Health Informatics Learning Goals and Courses.

Learning Goal	Course
An general overview of the field.	HINF 572: Health Informatics: An Overview
Advanced competencies in Health Sciences	HINF 511: Clinical Decision Support Systems HINF 551: Electronic Health Record Thesis HINF Coops
Advanced competencies in Information Sciences	HINF 550: Health Information Systems Design HINF 591: Database Design HINF 551: Electronic Health Record HINF 561: Project Management HINF 575: Human Factors in Healthcare HINF 591: Ethical and Legal Aspects of Health Informatics Thesis HINF Coops
Advanced competencies in Management Sciences	HINF 561: Project Management HINF 560: Health Care Quality Improvement HINF 510: Information Management and Technology HINF 562: Procurement in Health Informatics HINF 591: Ethical and Legal Aspects of Health Informatics Thesis HINF Coops
Advanced competencies in Health Informatics Research	HINF 503: Research Methods in Health Informatics HINF 573: Applied Biostatistics Thesis HINF Coops

health informatics students (who have undergraduate backgrounds in health informatics, computer science, engineering, medicine, other allied health disciplines and health services management).

Graduate student supervision follows existing policies within two Schools. Students are currently deciding upon potential thesis topics at the intersection of both disciplines and identifying potential supervisors from nursing and health informatics (i.e. as one faculty from each program is expected to co-supervise each student).

Many employers who have hired health informatics undergraduate and graduate students for cooperative learning or experiential learning work opportunities have expressed a desire to not only hire undergraduate and graduate students, but double degree students. Some employers expressed a specific interest in hiring individuals who have both nursing and health informatics competencies at the graduate level – cooperative education providing them with a opportunities to hire such individuals while they are still undertaking their studies. A number of employers identified a significant need for nurses who have competencies in both these areas (i.e. nursing and health informatics). Several employers (e.g. regional health authorities) rapidly identified positions in their organizations where there is a need for such individuals with such a unique set of abilities upon learning about the program. These positions have roles and responsibilities that are typical of job descriptions where health informatics professionals were asked to act as clinical analysts, clinical informatics specialists, nursing informatics specialists, research analysts, trainers and clinical informatics coordinators as outlined by the health informatics professional organization in Canada [34].

During cooperative learning experiences, students have identified they have encountered a general lack of understanding of the dual role of nurse-health informatics professional. Students have also reported that neither the information management nor the information technology staff understand that a student can have both skill sets at the graduate level (i.e. in nursing and health informatics). Although this was an initial educational challenge for students, once employers learned of and recognized students skills, they moved students into liaison roles between clinical and health informatics departments, and between system developers, implementers of information and communication technologies and end-users. Future work for faculty will include developing strategies to ease the transition for double degree students and employers (e.g. providing additional information about student's backgrounds and training/resources for employers to learn more about double degree student nursing and health informatics knowledge and skills).

A formal evaluation of the program is currently in the planning stages. Each of the Schools has continued with their existing program assessment plans as mandated by the University. An evaluation committee of faculty representing both programs has been formed to assess the combined evaluative data and to track alumni progress in the field after graduation.

6 Discussion

In summary, a partnership between the Schools of Nursing and Health Information Science at the University of Victoria, Victoria, British Columbia has led to the design and development of a new double degree program leading to a Masters in Nursing and Health Informatics. The three year distance education program relies on interleaving classroom learning and cooperative education or experiential learning experiences involving work on real-world HIS projects to solidify learning at the intersection of these two fields. There has been a significant and enthusiastic response to the launch of this program that links classroom to experiential learning by Baccalaureate prepared nurses who are interested in careers in nursing informatics and employers who are seeking out individuals with expertise in advanced practice nursing and health informatics.

Although challenges have been encountered in aspects related to initial course coordination, placement and integration of students in required cooperative work experiences, the program is now well underway. Furthermore, we are expecting increases in enrollments as the program continues into the future. We are continuing to obtain feedback from students, faculty and employers (through our cooperative education program) in order to fine-tune and iteratively update the program to address student learning needs and health and human resource issues in Canada.

Masters of Nursing programs do exist throughout Canada and are offered internationally. Furthermore, there are a variety of Biomedical and Health Informatics educational programs offered internationally. However, publications describing the design and implementation of a double degree program in nursing and health informatics have not been previously reported in the peer reviewed literature. To the best of our knowledge the double degree program in nursing and health informatics is the first of its kind, with the objective of combining the full competencies and strengths from two disciplines - nursing and health informatics. Furthermore, through integrating competencies from both nursing and health informatics, the double degree program is the first degree program to offer nurses both nursing and health informatics training at the graduate level in Canada.

References

[1] Kushniruk, A.W., Lau, F., Borycki, E., Protti, D. (2006). The School of Health Information Science at the University of Victoria: Towards an Integrative Model for Health Information science Education and Research. In Yearbook of International Medical Informatics, 159-165.

[2] Andersen, S. K., Klein, G. O., Schulz, S., Aarts, J. Mazzoleni, M. C. (2008). Ehealth beyond the horizon - Get IT there. Washington, D.C.: IOS Press.

[3] Lau, F. (2001). Health informatics education in Canada - What's Ahead? Electronic Healthcare, 1(2), 46-51.

[4] Protti, D. (2008). Adoption of information technology in primary care physician offices in New Zealand and Denmark, part 2: Historical comparisons. Informatics in Primary Care, 16, 189-93.

[5] Shorliffe , E. H. Cimino, J. J. (2006). Biomedical informatics: Computer applications in health care and biomedicine. New York: Springer Verlag.

[6] Canada Health Infoway (2009). The Infoway approach. Accessed at http://www.infoway-inforoute.ca/lang-en/about-infoway/approach (2009-04-05).

[7] Kushniruk, A. W. Borycki, E. M. (2008). Human, social and organizational aspects of health information systems. Hershey Pennsylvania: Idea Group.

[8] Canada's Health Informatics Association (COACH) (2009). Health informatics professional core competencies. COACH: Toronto.

[9] Mantas, J., Ammenwerth, E., Demiris, G., Hasman, A., Haux, R., Hersh, W., Hovenga, E., Lun, K. C., Marin, F., Martin-Sanchez, F., Wright, G. (2010). Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics: First revision. Methods of Information in Medicine, 49, 105-120.

[10] Canadian Nursing Informatics Association (2011). Nursing informatics. Accessed at http://www.cnia.ca/intro.htm (2011-06-15).

[11] Staggers, N. Bagley-Thompson, C. (2002). The evolution of definitions for nursing informatics. JAMIA, 9(3), 255-261.

[12] Hinegardner, P. G., Lansing, P. S. (1994). Nursing informatics program at the University of Maryland at Baltimore. Bulletin of the Medical Library Association, 82(4), 441-443.

[13] Hilz, L. M., Thompson, C. B. (2000). Expanding horizons in nursing: The clinical inforamtics graduate program. Online Journal of Nursing Informatics, 4(1), 1-16.

[14] Mantas, J. (1998). Developing curriculum in nursing informatics in Europe. International Journal of Medical Informatics, 50, 123-132.

[15] Greenes, R. A., Panchanathan, S., Patel, V., Silverman, H., Shortliffe, E. H. (2008). Biomedical informatics in the desert: A new and unique program at Arizona State University. IMIA Yearbook, 150-153.

[16] Valerius, J. D., Hersh, W. R. (2008). How well a biomedical informatics curriculum map to health information management knowledge clusters? Analysis of a program.. AMIA Annual Symposium Proceedings, 697.

[17] Demiris, G. (2007). Interdisciplinary innovations in biomedical and health informatics graduate education. Methods of Information in Medicine, 46, 63-66.

[18] Passareli, K. H. (2004). IT IQ in varying degress: Growing number of universities offering executives intensive education, distance learning in the field of biomedical informatics. Modern Healthcare, 24(43), 1-4.

[19] Goossen, W. T. F. (1996). Overview of health care and nursing informatics in the Netherlands. Health Informatics Journal, 2, 9-20.

[20] Van Bemmel, J. H. (2006). Assessment of education and research in biomedical informatics. IMIA Yearbook of Medical Informatics, 5-10.

[21] Haux, R. (2004). Biomedical and health informatics education at UMIT – approaches and strategies at a newly founded university. International Journal of Medical Informatics, 73, 128-128.

[22] Lopez- Campos, G., Lopez-Alonzo, V., Martin-Sanchez, F. (2010). Training health professionals in bioinformatics. Methods of Information in Medicine, 49, 299-304.

[23] Hasman, A., Albert, P., Wainwright, R., Klar, R., Sosa, M. (1995). Education and training in health informatics in Europe: State of the art. IOS Press.

[24] Zvarova, J. (2006). Biomedical informatics research and education at the EuroMISE Centre. IMIA Yearbook of Medical Informatics.

[25] Altuwaijri, M. M. (2010). Supporting the Saudi e-health initiative: The Master of Health informatics program at KSAU-HS. Eastern Mediterranean Health Journal, 16(1), 119-124.

[26] Curioso, W. H., Fuller, S., Garcia, P. J., Holmes, K. K., Kimball, A. M. (2010). Ten years of international collaboration in biomedical informatics and beyond: The AMAUTA program in Peru. JAMIA, 17, 477-480.

[27] Borycki E. M. Lemieux-Charles, L. (2009). Does a hybrid electronic-paper environment impact on health professional information seeking? Studies in Health Technology and Informatics, 136, 505-10.

[28] Covvey, D. H, Kushniruk, A., Fenton, S. (2005). The state of health informatics education in Canada. HCIMC, 2. Accessed at http://www.hcccinc.com/bcovers/previous /Vol_XX_No_2/pdfs/Covvey_Kushniruk_Fenton.pdf (2009-04-05).

[29] Diomidus, M., Mantas, J. (1998). Assessing the progress of the MSc course in health informatics uder the ERASMUS programme, International Journal of Medical Informatics, 50, 159-163.

[30] Roach, R. & Covvey, D. (2007). Co-operative experience in health informatics. Presented at COACH's Recruiting and Retaining HI Professionals Conference.

[31] COACH (2009). Canada's Health Informatics and Health Information Management Human Resources Report. COACH: Toronto.

[32] Urowitz, S., Wiljer, D., Apatu, E., Eysenback, G., DeLenardo, C., Harth, T Eysenbach, G. (2008). Is Canada ready for patient accessible electronic health records? A national scan. BMC Medical Informatics and Decision Making, 8, 1-7.

[33] Knaup, P., Haag, F. J., Leven, H., Dickhaus, H. (2009). Challenges in the evolution of the medical informatics program at Heidelberg/Heilbronnn (Germany). Methods of Information Medicine, 48, 66-75.

[34] Canada's Health Informatics Association (2010). Health informatics professional career matrix. Canada's Health Informatics Association: Toronto.

SNOMED CT: Who Needs to Know What?

Ed Conley[1,2], **Tim Benson**[1,3]

[1]Wellcome Trust Sintero Server Project, Cardiff University School of Computer Science & Informatics, UK

[2]Severnside Translational Research Alliance (SARTRE) at Cardiff and Bristol Universities, UK

[3]Abies Ltd, Hermitage, Berkshire, UK

Abstract

Adoption of SNOMED CT has not been as quick and easy as many people had hoped or expected. One reason is lack of education and hence understanding of what SNOMED CT does and how it works. We set out to answer the question "who needs to know what?" about SNOMED CT to help establish priorities for UK higher education. We devised an online questionnaire and obtained 177 responses, 51% health IT professionals, 42% clinicians. The sample was self-selecting of those with knowledge of SNOMED CT. The level of reported competence was greater among health IT professionals (33% rated themselves as competent) than among clinicians (5% rated themselves as competent) 92% of those who felt competent had received 3 or more days of training in SNOMED CT. This indicates the need for formal training in SNOMED CT. Most respondents indicated that health IT professionals ought to have a high level of competence in SNOMED CT, such that they are able to explain most if not all aspects of SNOMED CT to others. On the other hand, clinicians only require a fairly basic understanding.

Keywords

SNOMED CT, Medical Informatics, Education

Correspondence to:

Tim Benson
Abies Ltd
Address: 14 Pinewood Crescent, Hermitage,
Thatcham, Berkshire RG18 9WL, UK
E–mail: tim.benson@abies.co.uk

EJBI 2011; 7(2):40–47
received: June 20, 2011
accepted: September 29, 2011
published: December 23, 2011

1 Introduction

SNOMED CT is an acronym for Systematised Nomenclature of Medicine Clinical Terms. SNOMED CT is owned and managed by the International Health Terminology Standards Development Organisation (IHTSDO), based in Copenhagen, and is funded by direct contributions from governments. In 2011 these include: Australia, Canada, Cyprus, Denmark, Estonia, Lithuania, New Zealand, Singapore, Slovak Republic, Slovenia, Spain, Sweden, The Netherlands, United Kingdom and United States.

SNOMED CT has been given a central role as a core component of information technology strategy in many leading countries. For example, SNOMED CT is one of the coding schemes mandated in the US government's incentive program for meaningful use of electronic health records [1]. In the UK, the Department of Health has confirmed that it intends for SNOMED CT to be the sole supported terminology from 1st April 2015 [2].

Given its importance, it is reasonable to expect a high level of knowledge and understanding of it within the health informatics community. However, anecdotal evidence suggests that this is not the case.

Formally, SNOMED CT is a logic-based representation of meanings, organised in a directed acyclic graph. However, most people who use SNOMED CT do not understand the previous sentence, which demonstrates the problem.

We report a survey, which was designed to clarify two questions: how much do interested clinicians and health IT professionals already know about SNOMED CT, and who needs to know what.

SNOMED CT is a large, comprehensive, multilingual clinical terminology for use in computer systems. It comprises over 291,000 active clinical concepts, 758,000 English descriptions and 923,000 defining relationships (IHTSDO, 2010). By comparison, the main part of the International Classification of Diseases (ICD-10) has 10,760 items (excluding external causes). The sheer scale of SNOMED CT is one of the major challenges in using it.

SNOMED CT was developed by the College of American Pathology by merging its own SNOMED RT (Reference Terminology) with the NHS Clinical Terms Version 3 (CTV3), also known as the Read Codes Version 3. This work began in 1999 and the first release was on 31 January 2002.

The primary reason for developing SNOMED CT was the recognition that previous coding schemes, based on hierarchical taxonomic principles (tree-structures) were not 'fit-for-purpose'. Problems arising from older terminologies escalate over the years and it can be surprisingly hard to migrate from one version to another. The designers of SNOMED CT sought to address these problems and meet twelve specific requirements of a health terminology, which were summarised by Cimino [3].

1. **Concept orientation:** The idea of a concept with a single clinical meaning is the central tenet. Each concept has a single code or identifier and may be described using several human-readable terms which have the same meaning (synonyms) in one or more languages.

2. **Content:** Clinical terminologies need to be comprehensive in the breadth of the concepts included and the terms used to describe them and in the level of detail used. They require a robust means to incorporate changes (additions and deletions) and translation into other languages.

3. **Concept permanence:** Once a concept has been created it is persistent. It never disappears or changes its meaning.

4. **Non-semantic identifiers:** Semantic information is an attribute of a concept, not part of the identifier or code.

5. **Polyhierarchy:** Clinical concepts are naturally multi dimensional and can have multiple parents.

6. **Formal definitions:** Concepts in SNOMED CT are defined using a formal language expressing explicit computable relationships with other concepts.

7. **Rejection of NEC terms:** Catch-all categories such as "not elsewhere classified (NEC)" and "not otherwise specified (NOS)" are not used. This is because the meaning of an NEC class changes if a new category is added which includes some of its meaning.

8. **Multiple granularity:** Different types of user (clinicians, managers, policy makers) typically need different levels of information granularity.

9. **Multiple consistent views:** The coding scheme is viewable in different but consistent ways, so each user need only see what is relevant to them.

10. **Context representation:** Context (such as who made a statement, when and where) is an important aspect of medical data.

11. **Graceful evolution:** Terminologies need to change as knowledge develops, so the system evolves in a way that legacy data is preserved.

12. **Recognition of redundancy:** As systems change, concepts become redundant, but are not entirely deleted.

SNOMED CT is architecturally a substantial step forward over all previous systems with comparable scope. Its underlying structure means that changes can be incorporated relatively easily as the system evolves.

2 Scope of study

The need for more education and training in SNOMED CT is widely recognised, but many educators are unsure about what health IT professionals and clinical users of IT systems need to know. Little is known about the health informatics community's current level of knowledge, their expectations and perceived learning needs about SNOMED CT.

We set out to illuminate these questions, focusing on two broad groups – health IT professionals and clinical end users, mainly but not exclusively on the UK.

3 Method

We used an on-line survey tool, which permitted a mix of response types and an opportunity to test broad concept recognition patterns and elicit free ideas.

We used our own knowledge of SNOMED CT to make list a range of topics that could be relevant or interesting to the two broad survey groups of clinicians and health IT professionals. We only asked questions that we were genuinely interested to know how people would answer. The questions were worded in a way that we could not confidently predict the answer. The questionnaire was developed in a number of interactive sessions between the two authors; the beta version was piloted on ten subjects with varying knowledge of SNOMED CT.

The final version of the questionnaire was deployed using the Survey Monkey on-line questionnaire system, which also provides useful analysis facilities. We sent a single email invitation to several hundred people in the health informatics communities in the UK and internationally, including past attendees at SNOMED and HL7 conferences and training courses in the UK, to members of the BCS Primary Healthcare Specialist Group and the NHS Clinical Leaders network. The invitation directed recipients to the survey site. No reminders were sent.

The results were analysed primarily using the online tools provided by Survey Monkey.

4 Results

4.1 Respondent's Profile

177 respondents started the survey with 136 (76.8%) completing it. 20% of responses came from outside the UK, mainly health IT professionals.

Table 1 shows a balance between health IT professionals and other user roles. Respondents were able to select more than one role.

Table 1: Principal respondent job role.

Respondent role	All respondents
Health IT Professional	82 (50.9%)
Clinician	67 (41.6%)
Manager	12 (7.5%)
Other	18 (11.2%)

Respondents had a wide range of academic qualifications across different subject areas, which illustrates the multi-disciplinary nature of health informatics. The mean number of academic qualifications reported per respondent was 1.53 (Table 2).

Table 2: Respondents' academic qualifications.

Academic qualification	All respondents
Medicine	69 (41.6%)
IT/ computing / systems science	44 (26.5%)
Health Informatics	30 (18.1%)
Other clinical (e.g. nursing)	29 (17.4%)
Other technical (e.g. engineering)	38 (22.9%)
Other academic qualifications	45 (26.9%)
Qualifications/Respondents	**255/167 (1.53)**

4.2 Training and Education Experience

The amount of SNOMED CT training received is shown in Table 3. 26.9% of respondents had received 3 or more days of training, rather more than had received less than one day (13.5%) or one or two days training (15.2%).

This result was unexpected – we had expected a decrease in the numbers of respondents who had received more training. This is probably an artefact of this respondent population, which includes a high proportion of SNOMED experts.

Almost 50% of health IT professionals had received 3 or more days training in contrast to less than 8% of clinicians. Almost 70% of clinicians who responded had received no formal training in SNOMED CT, in contrast to 17% of the health IT professionals.

4.3 Competence

We found a strong relationship between respondent's self-reported knowledge/competence and the amount of formal training and education (in SNOMED CT) they had received (Table 4).

26 (17%) respondents rated themselves as competent, in comparison with 46 (27%) who had received three or more days training. Of those who rated themselves as competent in SNOMED CT, 92% had received three or more days training and education.

Unexpectedly few people feel competent on all aspects of SNOMED CT, and an important conclusion is that training for 3 or more days is probably needed to deliver a perception of competence. In this context, most SNOMED CT training courses only take 1 or 2 days.

28% of the respondents (74% of whom were clinicians) indicated that they knew nothing about SNOMED CT; the large majority of these answered "Don't Know" to most of the other questions. SNOMED CT is not "intuitively obvious"; it needs to be taught.

4.4 Detailed Understanding of SNOMED CT

We asked each respondent to say whether a series of eight statements about SNOMED CT were true or false or they did not know (Table 5). These statements were chosen to cover a range of subject areas, which might be covered in a clinical terminology course.

All of the statements are true. They are listed in order of the number of correct answers received. The number of "don't know" answers provides an indicator of which aspects of SNOMED CT are least well understood.

4.5 Knowledge Needs for Clinical Users

We asked which of these detailed aspects of SNOMED CT do clinicians need to know about (Table 6). The statements are listed in order of importance for clinicians to understand.

Most respondents (55%) reported that clinical users need to understand that SNOMED CT is important for information reuse; one third, that SNOMED CT concepts can have more than one parent in their hierarchy; others aspects had substantially lower scores, although all received some support.

These results support a conclusion that clinicians need to be taught a small number of basic principles about SNOMED CT.

4.6 Knowledge Needs for Health IT Professionals

We asked if health IT professionals should be able to explain each of these aspects of SNOMED CT (Table 7). Statements are listed in order of importance for health IT professionals to be able to explain.

The majority thought that health IT professionals should be able to explain most of these aspects of SNOMED CT. This is an important finding because most higher education courses in health informatics do not currently teach clinical terminology and SNOMED at the level that this implies.

These responses suggest that health IT professionals should be taught quite a lot about clinical terminology

Table 3: Amount of formal training and education in SNOMED CT.

Formal SNOMED CT Training Days	Clinician	Health IT Professional	All respondents
None	46 (69.7%)	14 (17.1%)	76 (44.4%)
Less than one day	10 (15.2%)	9 (11.0%)	23 (13.5%)
One or two days	5 (7.6%)	19 (23.2%)	26 (15.2%)
Three or more days	5 (7.6%)	40 (48.8%)	46 (26.9%)
TOTAL	66 (100%)	82 (100%)	171 (100%)

Table 4: Respondents' knowledge about SNOMED CT in relation to the amount of training received.

Knowledgeable about SNOMED CT	All respondents	3 or more days training
Competent	26 (16.7%)	24 (92.3%)
Intermediate	33 (21.4%)	13 (39.4%)
Novice	54 (34.6%)	4 (7.4%)
Know nothing	43 (27.9%)	0 (0%)
TOTAL	156	41 (26.3%)

Table 5: Respondents' knowledge of detailed aspects of SNOMED CT.

Aspect of SNOMED CT	True	Don't Know
SNOMED CT is important for information reuse	102 (66.2%)	46 (29.9%)
SNOMED CT concepts can have more than one parent in their hierarchy	90 (58.4%)	55 (35.7%)
SNOMED CT concepts may be defined by their relationships with other concepts	87 (56.5%)	62 (40.3%)
SNOMED CT is represented using either pre-coordinated concepts or post-coordinated expressions	72 (47.1%)	75 (49.0%)
The SNOMED CT concept model constrains what relationships are allowed	63 (41.2%)	79 (51.6%)
SNOMED CT uses variable length numeric codes	60 (39.2%)	66 (43.5%)
SNOMED CT Concepts are either fully defined or are marked as primitive	54 (35.1%)	94 (61.0%)
Subsumption-testing tests if one node is a child of another	43 (27.9%)	109 (70.8%)

including Description Logic, post-coordination and subsumption testing.

4.7 Why Learn SNOMED CT?

People need to be motivated to learn SNOMED CT. So, we asked about six possible reasons to learn it (Table 8). The results are shown in order of importance.

The most widely chosen reason for learning SNOMED CT was that it is an officially recognised standard. Government support for SNOMED CT is clearly a key factor.

Less than one third of the respondents said that helping their career was a very important reason for learning SNOMED. These results indicate that the incentives for individuals to learn SNOMED CT are not yet very strong.

4.8 Benefits of SNOMED CT

We asked whether SNOMED CT would be important in standardising a number of subject areas in health informatics (Table 9).

Almost two-thirds of respondents said that SNOMED CT will be "very important" in standardising interoperability (65%), data collection (65%) and clinical decision support (62%).

This positive view of the benefits of SNOMED CT, in contrast with the smaller number of people (30.4%) who said that learning SNOMED CT would be very important in helping their career, suggests that some respondents felt that the benefits of SNOMED CT are more likely to accrue to others, not necessarily themselves.

4.9 Barriers to Adoption

We know that the uptake of SNOMED CT has been slow, so we listed several of the most obvious barriers to the adoption of SNOMED CT, and asked respondents how strongly they agreed (Table 10). The strongest response was "I totally agree".

Our respondents rated the cost of training and educating staff in SNOMED CT to be the biggest barrier (59.4%), followed by the inherent complexity of SNOMED

Table 6: Do clinical users of the electronic health record need to understand the following aspects of SNOMED CT?

Aspect of SNOMED CT (Clinical users)	Definitely need to understand	Not at all
SNOMED CT is important for information reuse	83 (55.0%)	6 (4.0%)
SNOMED CT concepts can have more than one parent in their hierarchy	50 (33.3%)	20 (13.3%)
SNOMED CT concepts may be defined by their relationships with other concepts	34 (22.7%)	19 (12.7%)
SNOMED CT is represented using either pre-coordinated concepts or post-coordinated expressions	25 (16.8%)	26 (17.4%)
The SNOMED CT concept model constrains what relationships are allowed	17 (11.4%)	33 (22.1%)
SNOMED CT Concepts are either fully defined or are marked as primitive	11 (7.4%)	36 (24.2%)
SNOMED CT uses variable length numeric codes	7 (4.7%)	63 (42.3%)
Subsumption-testing tests if one node is a child of another	6 (4.1%)	44 (29.7%)

Table 7: Should Health IT professionals (e.g. at Masters level) be able to explain the following aspects of SNOMED CT?

Aspect of SNOMED CT (Health IT Professionals)	Definitely need to be able to explain	Not at all
SNOMED CT is important for information reuse	98 (68.1%)	2 (1.4%)
SNOMED CT concepts can have more than one parent in their hierarchy	93 (65.5%)	2 (1.4%)
SNOMED CT concepts may be defined by their relationships with other concepts	87 (60.8%)	3 (2.1%)
SNOMED CT is represented using either pre-coordinated concepts or post-coordinated expressions	82 (57.3%)	2 (1.4%)
The SNOMED CT concept model constrains what relationships are allowed	82 (57.3%)	3 (2.1%)
SNOMED CT uses variable length numeric codes	76 (53.1%)	6 (4.2%)
SNOMED CT Concepts are either fully defined or are marked as primitive	74 (51.7%)	3 (2.1%)
Subsumption-testing tests if one node is a child of another	68 (47.6%)	4 (2.8%)

Table 8: Reasons for learning SNOMED CT.

REASONS for learning SNOMED CT	Answered "Very Important"
SNOMED CT is the official standard coding scheme for exchanging clinical information in the NHS	77 (58.3%)
SNOMED CT is used internationally	76 (57.1%)
SNOMED CT is one of the cornerstones of Health Informatics	66 (50.0%)
SNOMED CT is comprehensive in a way that other coding schemes are not	60 (46.2%)
Knowing SNOMED CT will help my career	41 (30.4%)
We are already using SNOMED CT in house	34 (26.4%)

CT (57.5%) and the lack of good training and education materials (53.7%).

Technical issues such as post-coordination, data migration and finding the right code were also seen as significant barriers to adoption.

This clearly demonstrates that for this sample at least, the biggest barriers to the adoption of SNOMED CT can only be overcome by a greatly increased emphasis on education and training.

Table 9: Do you think that SNOMED CT will help in standardising.

Aspects for standardising	Answered "very important"
Interoperability	87 (64.9%)
Data collection	88 (64.7%)
Clinical decision support	84 (62.2%)
Analysis and research	80 (58.8%)
Retrieval and display of patient records	71 (53.0%)
Health service management	60 (44.1%)

Table 10: Barriers to the adoption of SNOMED CT.

Barriers to the adoption of SNOMED CT?	I totally agree
Cost and time needed to train staff	79 (59.4%)
SNOMED CT is inherently complex	77 (57.5%)
There is a lack of good training and education materials	73 (53.7%)
Post-coordination adds another layer of complexity	64 (47.8%)
Migration of legacy codes	63 (46.7%)
It can be difficult to find the right code	54 (40.0%)
The documentation is too long and complex	47 (35.1%)
Difficult to add your own local codes	30 (22.4%)

Table 11: Actual and desired ways of learning about SNOMED CT.

How did you learn about SNOMED CT?	How I learnt	Best ways to learn
Pick it up from colleagues	71 (55.0%)	89 (70.6%)
Read user guides and books	69 (53.1%)	77 (62.1%)
Face-to-face tuition/presentations	65 (50.4%)	121 (92.4%)
Learning by doing (e.g. practical examples)	58 (45.7%)	125 (96.2%)
Watching video / web presentations	22 (17.5%)	91 (74.0%)

Table 12: The most important aspects of SNOMED CT for the higher education curriculum.

Important aspects of SNOMED CT for higher education curriculum	High priority
Understanding how SNOMED CT works	85 (64.9%)
The strategic value of SNOMED CT	81 (62.3%)
Choosing the right code	70 (54.7%)
Use in interoperability	69 (53.5%)
The SNOMED CT concept model	67 (52.8%)
Analysis and reporting	59 (46.5%)
Mapping to / from other code systems	54 (42.2%)
Binding with information models	49 (38.9%)
Post-coordinated expressions	30 (24.0%)
Building sub-sets (ref-sets)	24 (18.8%)

4.10 Mechanisms for Learning about SNOMED CT

We asked how respondents had learnt SNOMED CT and how they thought people should learn (Table 11).

We found a difference between how people had learnt for themselves – picking it up from colleagues (55%), reading (53%) and face-to-face tuition (50%) – and their views of the best way to learn – learning by doing (e.g. practical examples) (96%), face to face tuition (92%) and watching video / web presentations (74%), although all methods had substantial support.

The survey confirms that people use a mix of learning strategies and one method will not suit everyone. These results suggest that e-learning (video/web presentations) should be part of the solution, but is not whole.

4.11 Curriculum Development

We asked respondents to select from a list, those items of highest priority for curriculum development (Table 12). The top priorities were understanding how SNOMED CT works (65%) and the strategic value of SNOMED CT (62%).

Fewer votes were given to more advanced topics such as post-coordination and building sub-sets (ref-sets). However a vote of 30 respondents (24%) saying that "post-coordinated expressions" should be "high priority" is a significant minority view.

5 Discussion

The main conclusion of this survey is that health IT professionals need to gain a substantially higher level of knowledge and expertise in SNOMED CT than most have today. There is a substantial gap between what health IT professionals need to know about SNOMED CT and what is taught in most universities and college courses on health informatics. In particular, we recommend that all health informatics professionals should learn Description Logic, which forms the basis of the way that SNOMED CT concepts are defined and post-coordinated expressions are put together.

There is a lack of adequate educational material on SNOMED CT which is fit for this purpose. Nine years after SNOMED CT was first released, not one book has yet been published that is devoted to it.

The Australian National e-Health Transition Authority (NEHTA) has published on YouTube two excellent video tutorials by Kent Spackman [4] with accompanying powerpoint sets [5]. However the total length is only about two and a half hours.

We have to educate the educators, but we lack sufficient well-qualified senior lecturers to motivate and educate their peers.

It is about thirty years since Blois [6] showed that clinical terminology is the key distinguishing feature of health IT, being central to medical thought and uniquely broad and deep. Clinical terminology is a core competence of health informatics. However, those who develop curricula for health informatics have not placed adequate emphasis on clinical terminology.

For example, the American Medical Informatics Association (AMIA) White Paper on Core Content for the Subspecialty of Clinical Informatics published in 2009 [7] lists clinical terminology as just one of 186 subject items. In 2010 IMIA revised its recommendations on education in health informatics [8], which includes references to 37 major publications on health informatics competencies. The new IMIA recommendations say "particular emphasis should be given to information literacy, health terminology, coding and classification systems, the electronic health record, and evaluation methodology", but only one item (1.17 Nomenclatures, vocabularies, terminologies, ontologies and taxonomies in BMHI) out of 48 listed knowledge/skill domains is explicitly devoted to clinical terminology.

Clinicians need a basic understanding of clinical terminology and SNOMED CT in particular but this need not include the technical details.

Access to SNOMED CT needs to be made easier. The whole of SNOMED CT should be made transparently accessible for inspection and review on the Internet. There are several adequate web-based browsers, but none support all of the facilities of SNOMED CT and each would benefit from further investment to make them more suitable as an educational resource.

Cooke [9] has suggested the following hierarchy of need to know:

- System designers and architects need to know everything!
- System configuration staff, information analysts and support staff need to understand the technical architecture and subsets/refsets.
- Trainers need to understand how searches work, but do not need to understand SNOMED CT structure.
- Clinicians need to know how to do searches, but no technical details of SNOMED CT.

This hierarchy is confirmed by this survey. Most respondents indicated that health IT professionals should have a high level of competence in SNOMED CT, such that they are able to explain most if not all aspects of SNOMED CT to others. On the other hand, clinicians only require a fairly basic understanding of clinical terminology. This survey is complementary to other surveys which focus on the completeness, accuracy and use of SNOMED CT itself [10].

Cornet and de Keizer analysed some 250 papers published between 1966 and 2006 related to the use of SNOMED in all its forms [11]. The two largest groups of papers concerned (1) comparisons of SNOMED with other terminologies and (2) those in which a theory such as automated coding, natural language processing or description logic is illustrated using SNOMED as an exemplar. They found little in the literature about the use of SNOMED in clinical practice. Educational challenges were not mentioned.

This study is necessarily limited to the respondents who chose to reply, and the responses were biased towards people who were already knowledgeable about SNOMED CT.

6 Conflict of Interest

Tim Benson's company (Abies Ltd) provides training courses in SNOMED CT.

Acknowledgements

We wish to thank all respondents for their time; the Department of Health Informatics Directorate for sponsorship of the work; Denise Downs Data Standards Implementation and Education Lead at Department of Health Informatics Directorate) for advice and support; Katherine Christensen (Knowledge Communities Implementation Manager, Informatics Development DH Informatics - Policy and Planning Directorate) for assistance with distribution of survey materials and John Gutai, Chief Technical Architect at the International Health Terminology Standards Development Organisation (IHTSDO) for advice.

References

[1] US Department of Health and Human Services. Health Information Technology: Initial Set of Standards, Implementation Specifications, and Certification Criteria for Electronic Health Record Technology: Final Rule. 45 CFR Part 170 Federal Register, July 28, 2010.

[2] Jones P. The UK Edition of SNOMED CT as the Fundamental Standard for Clinical Terminology within the NHS in England. Department of Health Informatics Directorate, 2011.

[3] Cimino J. Desiderata for controlled medical vocabularies in the twenty-first century. Methods Inf Med, 1998. 37(4-5): p. 394-403.

[4] YouTube: http://www.youtube.com/watch?v=ISfoMR4aygc and http://www.youtube.com/watch?v=CrZ46eXunzo

[5] IHTSDO: http://www.ihtsdo.org/publications/education-training.

[6] Blois M. Information and medicine: the nature of medical descriptions. 1984, Berkeley: University of California Press.

[7] Gardner R, et al. Core content for the subspecialty of clinical informatics. J Am Med Inform Assoc, 2009. 16(2): p. 153-7.

[8] Mantas J, et al. Recommendations of the International Medical Informatics Association (IMIA on Education in Biomedical and Health Informatics, First Revision. Methods Inf Med 2010;49:105-120 doi:10.3414/ME5119.

[9] Cooke M. Implementing SNOMED CT; Practicalities and Challenges. IHTSDO, 2009. http://www.ihtsdo.org /fileadmin/user_upload/Docs_01/Recourses/Implementing _SNOMED_CT/Implementing_SNOMED_CT _Practicalities_and_Challenges.pdf.

[10] Elhanan G, Perl Y, Geller J (2010) A survey of direct users and uses of SNOMED CT: 2010 Status. AMIA 2010 Symposium Proceedings 207-211. http://1.usa.gov/nFTxX7

[11] Cornet R, de Keizer N. Forty years of SNOMED: a literature review. BMC Medical Informatics and Decision Making 2008, 8(Suppl 1):S2 doi:10.1186/1472-6947-8-S1-S2

Educating Future Clinicians about Clinical Informatics: A Review of Implementation and Evaluation Cases

Kathleen Gray[1], **Ambica Dattakumar**[1], **Anthony Maeder**[2], **Helen Chenery**[3]

[1]University of Melbourne, Australia

[2]University of Western Sydney, Australia

[3]University of Queensland, Australia

Abstract

There is growing consensus that future health professionals need specific learning activities in their entry level training that build their clinical informatics competency. This study aims to give insights into how clinical informatics education has worked in the past, and to suggest future directions for delivering ongoing curriculum reform in this important aspect of health professional education. The literature of the past decade on implementation and evaluation of clinical informatics education for future health professionals was reviewed, including accounts from medicine, nursing, dentistry, allied health, complementary therapies and interprofessional education. Selected papers were analysed for information about the intended competencies or learning outcomes; the content covered; the relationship of the curriculum to standards and accreditation; the teaching methods and modes of delivery; assessment of student learning; and evaluation of educational quality. It appears that the literature needs to give further attention to the pedagogy of clinical informatics education, starting from what is considered educational good practice in other areas of knowledge and skill in the health professions. A clear rationale for teaching clinical informatics and a detailed list of desired competencies are an important start but do not, on their own, explain how to achieve effective learning experiences or intended educational outcomes.

Keywords

Clinical informatics, Education, Evaluation, Health informatics, Health professions, Implementation

Correspondence to:

Kathleen Gray
Health and Biomedical Informatics Research Unit
Faculty of Medicine, Dentistry and Health Sciences
& Department of Information Systems
Address: The University of Melbourne VIC 3010 Australia
E-mail: kgray@unimelb.edu.au

EJBI 2011; 7(2):48–57
received: July 16, 2011
accepted: October 5, 2011
published: December 23, 2011

1 Background

Information and communication technologies (ICTs) are an increasingly influential part of the working environment and work practices of all clinical health professionals, in medicine, nursing, dentistry, allied health and complementary therapies. Over the past decade this change has been driven by the universal move towards electronic health record systems (EHRs) for patients as well as widening availability of sophisticated tools and technologies for clinical decision support and the rise of online information accessible to patients and consumers of health services. A key factor in ICT uptake within the health sector is the adoption of system-wide government-led approaches to healthcare reform that focus on 'health information technology' (e.g. US Office of the National Coordinator for Health Information Technology), 'national IT infrastructure' (e.g. UK National Health Service Connecting for Health), and 'national eHealth strategy' (e.g. Australian National eHealth Transition Authority). The generality and comprehensive nature of these approaches suggest the need for new initiatives in entry-level education, training, learning and development in the health professions, according to Liaw and Gray [1].

"Clinical informatics", as this component of health professional knowledge and skills is known, is far more than just training in how to use technological tools. Elaborating on Hersh [2] we define clinical informatics to mean the application of health and biomedical informatics within clinical professional practice (i.e. in those professions which involve observing and treating patients directly). While it is possible in some clinical professions to gain advanced qualifications leading to a sub-

Table 1: Medicine.

Medicine (UK)	Preparing tomorrow's doctors: The impact of a special study module in medical informatics [15]
Learners / learning need	Elective course for first-year medical students Doctors need to be equipped with the attitude and tools to deal with and exploit advances in computing and the Internet.
Competencies / outcomes	Appropriate knowledge, skills and attitudes to ICT To access information from databases About information flows and information systems
Content	Managing data and information Knowledge engineering and decision support Communication and the Internet Data security and confidentiality Evaluating software and systems Using PowerPoint for presentations Searching online information sources and databases
Standards / accreditation	Benchmarked against UK, US and Australian report and journal literature on medical IT literacy.
Teaching methods / mode	Taught in second semester of first year, in 3 two-hour sessions per week for 12 weeks, including lectures, hands-on computer work, and field trips to see clinical computing systems in situ.
Assessment	Individuals used online resources to research a medical topic, then shared findings and comments online with peers. Groups wrote reports about a working clinical system and a patient survey and presented findings in class.
Evaluation	Students were surveyed before and after the course: its impact on their IT skills was not significant, but student feedback was consistently positive in all areas.
Related cases	[16]

specialisation as a clinical informatician, our focus in this paper is on future clinicians. The related curriculum needs to build capability or competency, that is, the more integrated, resilient form of knowledge, skill and attitude expected of a graduate professional, as defined by Govaerts [3]:

Competency is the (individual) ability to make deliberate choices from a repertoire of behaviours for handling situations and tasks in specific contexts of professional practice, by using and integrating knowledge, skills, judgement, attitudes and personal values, in accordance with professional role and responsibilities. Competency is to be inferred from task behaviour, outcomes and the justification of choices that have been made, as well as from reflection on performance and performance effects.

There is growing consensus that future health professionals need to be exposed to specific learning activities in their entry level training that build their clinical informatics competency, for example Smith and colleagues [4]. Some peak bodies in the health professions have recognised the need for such education and some of these bodies have specified the relevant types of knowledge and skills that health professionals ought to have. Two Australian examples are nursing [5] and general practice [6] Internationally, some health professions are still at early stages in this work, for example dentistry [7] and social work [8]. It is clear, however, that progress towards identifying core levels and amounts of ehealth curricula has been slow and fragmented.

The peer-reviewed literature of clinical informatics education offers a variety of recommendations on what to teach to students who are qualifying in a health profession, and why to teach it. However, there is a paucity of literature that goes beyond learning needs, competency specifications and content outlines. It would be most helpful to curriculum designers and educators to be informed by literature that elaborates on what is involved in making such education a reality and on the experience of staff and students who participate in it. This gap in the literature has been identified by Van Veen and colleagues as an issue for informatics broadly [9].

The literature of health professional education recognises that curriculum is both an entity and a process. As an entity it comprises not only the expected competencies and roles; but also the learners at the centre of the enterprise; assessment linking competencies and learners; the conditions and resources for learning; and the social, political and cultural context in which the learning occurs. As a process it comprises design, implementation, evaluation and renewal [10].

Given this more extensive view of curriculum, clinical informatics education initiatives need to be able to refer to

Table 2: Nursing.

Nursing (USA)	Effect of an informatics for evidence-based practice curriculum on nursing informatics competencies [17]
Learners / learning need	Non-nurses with a Bachelor's degree, enrolled in a 3-year program leading to a Master's degree and professional practice as advanced practice nurses. Informatics competence is a prerequisite for professionals to optimally use information technology to promote patient safety and to enable evidence-base practice.
Competencies / outcomes	(2003 iteration) Analyse clinical case studies using diagnostic decision support tools Critically analyse a clinical decision rule for validity and utility in nursing practice Assess the strengths and weaknesses of selected decision support programs for application in nursing practice Create, solve and interpret a simple decision tree using software that supports expected value decision making methods Apply clinical and theoretical expertise to the review of interactive health communication resources Critically analyse web-based health content for literacy level and accuracy of information for clinical populations Select appropriate materials for a target population's health information and education needs related to a specific topic Develop a user-friendly health information and education web page on a chosen topic
Content	Decision-making and decision support Web-based health information for consumers
Standards / accreditation	Benchmarked against US report and journal literature on nursing informatics competencies.
Teaching methods / mode	(2003 iteration) Two year-long 1-credit informatics intensives, with didactic and laboratory classes PDA based clinical log using Home Health Care Classification terminology Mainstreaming of some competencies into core or specialty curriculum
Assessment	Students used their PDA to document a standard set of data elements related to patient demographics, medical and nursing diagnoses and nursing interventions, and to access evidence-based practice resources, and synchronized their data to a central repository every two weeks. Students critically evaluated health education sites on the Internet.
Evaluation	Student learning was evaluated using in-class pre-and post-tests of self-reported competency in documentation, decision support, data, privacy/security and evidence-based practice. Results were mixed, and it appears that educational strategies were not closely enough integrated with tested competencies to show substantial positive effects.
Related cases	[18, 19, 20, 21]

rich descriptions and critical discussions of teaching and learning strategies and methods; of the alignment of assessment with objectives and standards; of approaches to quality management and continuous improvement. Initiatives to address the need for clinical informatics education among future health professionals should thus aspire to be scholarly, that is "work upon which other scholars can build and equally important that other scholars can review, assess and critique [11]". It should be evidence-based - for example, Patel and colleagues [12] offers an example of applying empirical findings from the learning sciences to the development of curricula. It should be modelled on good practice; for example, Kaufman [13] offers "seven principles to guide teaching practice", namely that learners should have opportunities to: be active contributors; work on real life problems; proceed from their current knowledge; use self direction; practice and get feedback; reflect on their practice; and learn from role models.

Therefore, this study uses ideas underpinning these aspirations and fundamental to an entity and process view of curriculum as the basis for a selective review of the literature on implementation and evaluation of clinical informatics education for future health professionals. This study aims to give insights into how clinical informatics education has been approached in the past, and it aims

Table 3: Dentistry.

Dentistry (USA)	Development of an interdisciplinary course in information resources and evidence-based dentistry [22]
Learners / learning need	Required course for first-year dental students Dentists must be knowledgeable about and keep up with the latest developments to make informed choices to improve patient care.
Competencies / outcomes	Students would be able to: Use critical thinking and problem solving related to comprehensive care of patients Use information technology resources in contemporary dental practice
Content	Evidence-based dentistry Information databases and search strategies Structure and evaluation of scientific information Dental Informatics
Standards / accreditation	The degree accrediting body required that graduates have expertise in information management and critical thinking.
Teaching methods / mode	The course ran in the first half of the first semester. It consisted of 5 lectures, 1 hour of practical training on database searching and 1 hour of class discussion on clinical search topics chosen by the students.
Assessment	Students had to complete two online questionnaires, email the results of their search completed in the practical session to the librarian, and do an individual written assignment that evaluated one of the resources that was used to get an answer to the clinical question. In the final session, students had to work in small groups and discuss their individual assignment. They then presented it to the class as a whole.
Evaluation	Students completed an online evaluation at the end of the course: feedback was positive overall.
Related cases	[23]

to distil lessons and suggest future directions for delivering ongoing curriculum reform in this important aspect of health professional education.

2 Methods

This study adapted from Bordage and Harris [10] a set of key themes that could be used to systematically review the literature on implementation and evaluation of clinical informatics education for future health professionals:

- learners and their need to learn clinical informatics;
- the intended competencies or learning outcomes;
- the content covered;
- the relationship of the curriculum to standards and accreditation;
- the teaching methods and modes of delivery;
- assessment of student learning;
- evaluation of educational quality.

For the purpose of this review, relevance was defined as peer-reviewed journal and conference literature published in English, between the years 2000-2011, and covering university teaching of (bio-)medical / clinical / health informatics to future clinicians. We used the Australian Standard Classification of Occupations in medicine, nursing and miscellaneous health professions as our starting point for ensuring wide coverage of the clinical professions. Papers identified during our search which we subsequently excluded were those focussing on continuing professional development for qualified health professionals, or on informatics for advanced clinical specialties (such as psychiatry, oncology nursing, etc.) or on health informatics as a specialist degree in its own right.

A limitation of this method is that it did not include non-peer-reviewed literature. There is significant report literature by reputable agencies that should not be overlooked by those interested in this aspect of health professional education. However this literature tends to make recommendations and provide high-level reviews of activity, rather than to give details of actual educational implementation or evaluation, and so does not fit the aims of this study.

A five-step methodology was used to select the papers included in this review of implementation and evaluation cases.

Step 1: Google Scholar was used as a starting point to rapidly and easily scope the volume and characteristics of the literature, a widely used and recognised technique [14]. The search terms used are in Appendix A. Selection of papers to retrieve in full-text

Table 4: Allied health.

Allied health (USA)	Library- sponsored instruction improves core informatics competencies among allied health students [24]
Learners / learning need	Required course for first-year students in occupational, physical and respiratory therapy Health care professionals must contend with the growth of biomedical knowledge and advances in information technology and exercise sophisticated information management skills in clinical education.
Competencies / outcomes	Appraise and evaluate the quality of information Appreciate ethical, legal, and socioeconomic aspects of information and its technologies Develop an appreciate for information literacy and lifelong learning Exercise best practices for integrating information into clinical decision making Organize and communicate information effectively Recognize the need for information Understand how to access information from appropriate sources
Content	Information searching on MEDLINE, CINAHL, PubMed, Web of Science, and using text book and journal resources Evidence based practice and tools – using the 'PICO' model to form clinical questions to search databases, appraising the information based on the quality of the information and judging the applicability of the article to a clinical scenario Presentation tools such as MS PowerPoint, MS Publisher and Adobe Photoshop Use of statistical analysis and data management tools such as MS Excel and SPSS Relational databases– normalization, table and query formation, relationship design, MS Access
Standards / accreditation	Benchmarked against the University Library's information literacy competencies. Accreditation of occupational, physical and respiratory therapy degree programs by their professional associations required inclusion of informatics training in the curriculum.
Teaching methods / mode	Taught as a combination of lectures and labs, 3 hours per week over 7 weeks. Separate classes for students in each allied health degree.
Assessment	Group and individual assignments and group presentations of research.
Evaluation	Pre-test / post-test / post-test and self assessment instruments were used to measure whether the course objectives had been achieved: instruction had a positive effect on student learning, confidence and satisfaction.
Related cases	[25, 26]

was based on the title of the article and the abstract. An indicative corpus of literature (comprising about 30 papers) was found in this way.

Step 2: Next, databases related to the medical field and education fields (MEDLINE, ERIC, CINAHL, Scopus and Web of Science) were searched. MeSH terms in Appendix B were used to search these databases. This step retrieved approximately 100 additional papers.

Step 3: The reference list at the end of every paper identified in step 1 and step 2 was checked to find further papers. Those that were deemed relevant on the basis of title were sourced in full-text. By this stage around 200 papers had been retrieved.

Step 4: Each paper was read by two researchers at doctoral level with information science and information systems expertise, and categorised according to the clinical health profession on which it focused. Within each profession, each paper was further analysed according to the key curriculum themes. Some of these papers were excluded, once reviewed, because they did not address the majority of these themes, for instance if they predominantly reported on curriculum proposals, teaching tool trials, or the general state of student and staff attitudes and skills. A shortlist of fewer than 20 papers resulted.

Step 5: From these papers we selected six papers to summarise. The selection of these six papers from the shortlist at step 4 was reviewed by two additional researchers at professorial level with health informatics and health sciences expertise. We sought to present a selection that gave a balance of professions and of approaches over the decade, particularly for an audience of health profession educators who may not have considered this area of curriculum

Table 5: Complementary medicine.

Complementary medicine (USA)	The introduction of a medical informatics course into a medical school curriculum [27]
Learners / learning need	Required course for first year osteopathy students How to access and evaluate information that is required to resolve a clinical situation needs to be taught at a university level rather than clinicians entering the workplace and then learning the skills.
Competencies / outcomes	Answer basic questions about information, information systems and the role of information literacy and informatics in health care Design and deliver an informed presentation of a clinical case Develop effective search strategies and apply them to selected databases Evaluate and synthesise information retrieved in a search Recognise the need for case-specific information and articulate a well-formed question
Content	Classification of information and where it is located. How to verify the quality, accuracy of the information Presenting information to different audiences and using PowerPoint
Standards / accreditation	Course design was benchmarked against US medical schools.
Teaching methods / mode	1-year, for-credit course. The first 9 contact hours consisted of 3 lectures.
Assessment	A Student Grand Rounds presentation was the major assessment. Students worked in groups of 9 on a case allocated to them depending on the physiological system that they were studying at the time. They had to research the case, write a report and present it to hospital faculty and students. There were also quizzes in the lectures, two reflective pieces of writing about research, and self- and peer evaluation. The course was graded Pass or Fail.
Evaluation	Analysis of student self- and peer evaluation Course team of librarians, clinical teaching staff and lab researchers met regularly.
Related cases	[None found]

previously. This offers a starting point for reflecting on how educational implementation and evaluation may best be done in one's own distinctive disciplinary and organisational context. We recognise that none of these papers can tell the full story about any instance of clinical informatics education. Further, we do not intend to appear to recommend the approaches described at the expense of those we left out, and have therefore included citations for all additional papers on our shortlist, each one associated with the professionally related case we summarised.

3 Findings and Discussion

The findings presented here give an overview of diverse approaches during the past decade to informatics education for future clinicians across the health professions internationally:

- Medicine (Table 1).
- Nursing (Table 2).
- Dentistry (Table 3).
- Allied Health (Table 4).
- Complementary Medicine (Table 5).
- Interprofessional (Table 6).

We found very few accounts of the implementation or evaluation of clinical informatics education in most health professions. In reality, there may be a great deal of unreported reflective and scholarly practice in this field, which educators should be encouraged to share via conferences and journals. At present nursing cases are the most abundant source of implementation and evaluation ideas in the literature, which may serve as useful models for other health professions.

Across the health professions, the general aims and outcomes of these programs of study are not radically different from one to another. In educational settings where future clinicians are enrolled and trained for more than one profession, there are obvious logistical arguments for sharing elements of clinical informatics education among health professions. Our comparison of curriculum aims and outcomes, combined with the evidence from the interprofessional cases themselves, suggests that there are pedagogical reasons for interprofessional learning as well.

Table 6: Interprofessional.

Interprofessional (USA)	An interdisciplinary online course in health care informatics [28]
Learners / learning need	Elective course for third-year pharmacy students plus students from public health, nursing, and Information and library science at a similar stage in their degree Innovations in technology mean that health care providers have to become proficient at appropriately using technology to deliver high quality health care services.
Competencies / outcomes	Appreciate the perspectives and roles of patients and providers when using technology in care Make decisions about the value and ethical applications of specific technologies Understand how to incorporate technology into the provision of safe, effective and evidence-based health care
Content	Clinical decision support systems and patient safety Consumer health Electronic health records and computerised order entry Health care terminologies and coding Information management and evaluation Patient care management and monitoring Public health informatics Security, privacy and ethics Telehealth
Standards / accreditation	Benchmarked using a workshop of practicing pharmacists, a literature review and curriculum committee review
Teaching methods / mode	Initial orientation meeting, then taught online via a 20 minute lecture each week provided as PowerPoint slides with voiceovers and ancillary learning resources, in a Blackboard learning management system. Students had to complete weekly activities, then do a feedback exercise before moving onto the next set of slides.
Assessment	Self-assessment quizzes and weekly activities. Each student did an informatics project of their choice and presented it, using voice-annotated PowerPoint slides accessible via the Blackboard page, for peer and instructor review.
Evaluation	Online survey about each week's module and comprehensive online survey at the end of the course: generally positive. Analysis of student work: consistently met or exceeded the course expectations. Substantial increase in enrolments the following year.
Related cases	[29, 30]

A number of relevant cases we found used the language and standards of information literacy and / or evidence-based medicine to describe an essentially informatics-oriented unit of study. The use of "ehealth" to describe this area of education is also growing, for example [31]. It is interesting to note that interdisciplinary teaching teams are often involved, which may include clinical educators, biomedical scientists, biomedical librarians and, perhaps not often enough, expert health informaticians.

The recommendations of the International Medical Informatics Association for 19 essential elements of core biomedical and health informatics knowledge and 14 of informatics / computer science [32] were available in their first iteration during the period these cases represent. It is clear, and concerning, that these recommendations do not seem to have been be very influential in the formulation of desired competencies and course content in the cases we reviewed. Future curriculum development needs to close the gap between the particular health profession, and the profession and discipline of health informatics.

Choice of compulsory or elective study for the clinical informatics curriculum is a notable point of difference across these cases. Explicit requirements by an external accrediting body are not always in evidence. Failing these, strong academic leadership within the educational institution is essential to address students' perceived learning needs by making provision for all future clinicians to be educated sufficiently in informatics.

A related decision is when in a multi-year degree program to introduce informatics and how much emphasis to give to this content, with options ranging from a short, sharp first-semester-of-first-year learning experience to a later-year or capstone experience. The teaching, learning and assessment methods may be as important as the timing in influencing the way that future clinicians are able to consolidate and extend their initial development of informatics knowledge, skills and attitudes. The option of integrating the content into many subjects in every year of the degree is infrequently described, and the nursing case we summarised suggests that this is more challenging to achieve than a stand-alone subject, but potentially more effective too.

There is scope for creativity in selecting methods and modes of instruction; lectures and computer lab sessions can be supplemented by field studies and field work with a strong applied focus. The possibilities for using elearning, simulations and personal or mobile technologies do not appear to be fully exploited in most cases. We note that innovations of this kind are sometimes reported in the literature in a way that is rather decontextualised from the pedagogical themes on which this paper focuses.

The alignment between intended learning outcomes and methods used to assess student learning is not very fully described in many case reports. The ability to develop competence to practice underlies many of the needs analyses, and yet the design and conduct of assessment to demonstrate such competence is relatively underdeveloped, with no apparent use of externally validated instruments or processes. This is an area where clinical informatics education needs to heed what is considered good practice in other areas of clinical knowledge and skill.

4 Conclusion

Many of the papers we sighted were focused strongly on the rationale or argument for teaching clinical informatics. This is an indicator the long and complex journey toward recognition of informatics generally as a core competency for future health professionals. In the current international climate of system-wide implementation of ehealth, it is timely to take the theory and the practice of clinical informatics education to a more sophisticated level in a scholarly and supportive community of practice within and across the health professions. Areas of current research interest across the tertiary education sector – such as e-assessment, globalisation, learning analytics, research-infused teaching, service learning, using social media for learning, sustainability and threshold concepts, to name a few – may offer worthwhile starting points for further pedagogical inquiry into clinical informatics education.

Acknowledgements

The authors wish to acknowledge the influences on this paper of another member of their clinical informatics education project team, Kerryn Butler-Henderson, the biomedical librarian who advised on the search strategy, Jim Berryman, and the colleague who translated the paper from English to Spanish, Fernando Martin Sanchez.

This work has been supported in part through the Australian Learning Teaching Council Priority Projects fund. The views expressed in this work do not necessarily reflect the views of the ALTC.

References

[1] Liaw S. T., Gray K.: Clinical Health Informatics Education For A 21st Century World. In: E. Hovenga, M. Kidd, S. Garde, C. Cossio (Eds.). Health Informatics: An Overview. (Studies in Health Technology and Informatics, vol. 151). Amsterdam, Netherlands, IOS Press, 2010, pp. 479-491.

[2] Hersh W.: A Stimulus To Define Informatics And Health Information Technology. BMC Medical Informatics and Decision-Making 2009; 9(24), [6pp.] doi:10.1186/1472-6947-9-24

[3] Govaerts M.: Educational Competencies Or Education For Professional Competence? Medical Education 2008; 42 (3), pp. 234-236.

[4] Smith S., Drake L., Harris J., Watson K., Pohlner P.: Clinical Informatics: A Workforce Priority For 21st Century Healthcare. Australian Health Review 2011; 35, pp. 130-135.

[5] Foster J., Bryce J.: Australian Nursing Informatics Competency Project. In: Proceedings of the 10th International Congress on Nursing Informatics: Connecting Health and Humans, 28 June - 1 July 2009, Helsinki. Retrieved July 4, 2011, from http://eprints.qut.edu.au/31927/1/c31927a.pdf

[6] Tse J., O'Shea C.: Getting Runs On The Scoreboard - Development Of A Formal Health Informatics Curriculum Statement For The RACGP. In: H. Grain, (Ed). HIC 2008 Conference: Australia's Health Informatics Conference; The Person in the Centre, August 31 - September 2, 2008 Melbourne Convention Centre. Brunswick East, Vic., Health Informatics Society of Australia, 2008, pp. 210-213.

[7] Schleyer, T.: Dental Informatics: A Work In Progress. Advances in Dental Research 2003; 17, pp. 9-15.

[8] Parker-Oliver D., Demiris G.: Social Work Informatics: A New Speciality. Social Work 2008; 51(2), pp. 127-134.

[9] Van Veen M., Mulder F., Lemmen K.: What Is Lacking In Curriculum Schemes For Computing/Informatics? In: ITiCSE '04 Proceedings of the 9th annual SIGCSE conference on Innovation and technology in computer science education. ACM New York, NY, USA, 2004, pp. 186-190. doi:10.1145/1007996.1008046

[10] Bordage G., Harris I.: Making A Difference In Curriculum Reform And Decision-Making Processes. Medical Education 2011; 45, pp. 87-94. doi:10.1111/j.1365-2923.2010.03727.x

[11] Shulman L.: The Scholarship Of Teaching And Learning: A Personal Account And Reflection. International Journal for the Scholarship of Teaching and Learning 2011; 5(1), [7pp.]. Retrieved July 4, 2011, from http://academics.georgiasouthern.edu/ijsotl/v5n1/featured _essay/PDFs/_Shulman.pdf

[12] Patel V., Yoskowitz N., Arocha J., Shortliffe E.: Cognitive And Learning Sciences In Biomedical And Health Instructional Design: A Review With Lessons For Biomedical Informatics Education. Journal of Biomedical Informatics 2009;, 42(1), pp. 176-197. doi:10.1016/j.jbi.2008.12.002

[13] Kaufman D.: Applying Educational Theory In Practice. In: D. Cantillon, L. Hutchinson, D. Wood (Eds.). ABC of Learning and Teaching in Medicine. London, BMJ Books, 2004, pp. 1-4.

[14] Hightower C., Caldwell C.: Shifting Sands: Science Researchers on Google Scholar, Web of Science, and PubMed, with Implications for Library Collections Budgets. Issues in Science and Technology Librarianship 2010; 63, Article 3. Retrieved September 29, 2011, from http://www.istl.org/10-fall/refereed3.html

[15] McGlade K., McKeveney C., Crawford V., Brannigan P.: Preparing Tomorrow's Doctors: The Impact Of A Special Study Module In Medical Informatics. Medical Education 2001;, 35, pp. 62-67.

[16] Zelnick C., Nelson D.: A Medical Informatics Curriculum For 21st Century Family Practice Residencies. Family Medicine 2002; 34(9), pp. 685-691.

[17] Desjardins K., Cook S., Jenkins M., Bakken S.: Effect Of An Informatics For Evidence-Based Practice Curriculum On Nursing Informatics Competencies. International Journal of Medical Informatics 2005; 74, pp. 1012-1020. doi:10.1016/j.ijmedinf.2005.07.001

[18] Gassert C., Sward K.: Phase I Implementation Of An Academic Medical Record For Integrating Information Management Competencies Into A Nursing Curriculum. In: K. Kuhn (ed.). MEDINFO 2007. Amsterdam: IOS Press, 2007, pp. 1392-1395.

[19] Jacobs S., Rosenfeld P., Haber J.: Information Literacy As The Foundation For Evidence-Based Practice In Graduate Nursing Education: A Curriculum-Integrated Approach. Journal of Professional Nursing 2003; 19(5), pp. 320-328.

[20] Shorten A., Wallace M., Crookes P.: Developing Information Literacy: A Key To Evidence-Based Nursing. International Nursing Review 2001; 48, pp. 86-92.

[21] Sockolow P., Bowles K.: Including Information Technology Project Management In The Nursing Informatics Curriculum. CIN: Computers, Informatics, Nursing 2008; 26(1), pp. 14-20.

[22] Levine A., Bebermeyer R., Chen J.-W., Davis D., Harty C.: Development Of An Interdisciplinary Course In Information Resources And Evidence-Based Dentistry. Journal of Dental Education 2008; 72(9), pp. 1067-1076.

[23] Ford P., Hibberd K.: Creating Effective And Engaging Information Literacy Programmes For The Dental Curriculum. European Journal of Dental Education 2010; 15, pp. 1-6.

[24] Van Moorsel G.: Library-Sponsored Instruction Improves Core Informatics Competencies Among Allied Health Students: A Research-Based Case Study. Journal of Allied Health 2005; 34(3), pp. 145-152.

[25] Harrison J., Stewart J.: Training In Pathology Informatics: Implementation At The University Of Pittsburgh. Archives of Pathology and Laboratory Medicine 2003; 127, pp. 1019-1025.

[26] Hersh W., Gorman P., Ruback T., Kenney-Moore P.: Medical Informatics And Evidence-Based Medicine For Physician Assistants: Implementation And Evaluation Of Curriculum. Perspective on Physician Assistant Education 2002; 13(1), pp. 7-10.

[27] Schwartz B.: The Introduction Of A Medical Informatics Course Into A Medical School Curriculum. Medical Reference Services Quarterly 2011; 30(1), pp. 74-82.

[28] Brock T., Smith S.: An Interdisciplinary Online Course In Health Care Informatics. American Journal of Pharmaceutical Education 2007; 71(3), Article 43. Retrieved July 4, 2011, from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1913289/

[29] Hart J., Newton B., Boone S.: University Of Arkansas For Medical Sciences Electronic Health Record And Medical Informatics Training For Undergraduate Health Professionals. Journal of the Medical Library Association 2010; 98(3), pp. 212-216. doi:10.3163/1536-5050.98.3.007

[30] Masic I.: Medical Informatics Education At Medical Faculty Of Sarajevo University – 15 Years Experience. Acta Informatica Medica 2008; 16(1), pp. 4-9.

[31] Clark J., Baker B., Baker D.: Getting Ehealth Into Basic Nursing Education: Report Of The RCN Information In Nursing Project. Studies in Health Technology and Informatics 2009; 146, pp. 534-539.

[32] Mantas J., Ammenwerth E., Demiris G., Hasman A., Haux R., Hersh W., Hovenga E., Lun K., Marin H., Martin-Sanchez F., Wright G.: Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision (IMIA Recommendations on Education Task Force). Methods of Information in Medicine 2010; 49(2), pp. 105–120. doi: 10.3414/ME5119

A Search terms used in Google Scholar

- Australian curriculum framework
- Canadian informatics framework
- Clinical informatics curriculum
- Clinical informatics education
- Clinical informatics education in Australia
- Clinical informatics education in South America
- Clinical informatics for allied health professionals
- Competencies of medical practitioners in Australia
- Computer literacy and medical students
- Curriculum for health informatics
- Curriculum for medical education should include ehealth
- Education of clinicians in Australia
- Ehealth education
- Ehealth in dentistry education
- Health informatics and education
- Health informatics competency in Australia
- Health informatics education
- Health informatics education in Australia
- Health informatics skills for allied health professionals
- How to teach clinical informatics at universities
- Importance of health informatics curriculum
- Informatics for clinicians in universities
- Informatics in curriculum of medical degrees

- Information literacy and healthcare professionals
- Medical informatics and interdisciplinary teaching
- Medical practitioners education in Australia
- Rationale for learning health informatics
- Review of ehealth education in universities
- Review of health informatics curriculum in Australia
- Review of medical education in Australia
- Teaching and assessing health informatics at universities
- Teaching e-health at universities
- Teaching ehealth to students
- Teaching of electronic health at universities
- TIGER framework
- Why is ehealth important?
- Why is teaching clinical informatics important?

B MeSH terms used in database searches

Interdisciplinary OR Interprof*
AND
Clinic* OR Allied Health OR Public Health OR Acupuncture OR Ambulance Professionals OR Paramedicine OR Audiology OR Chiropractic OR Counselling OR Dentistry OR Exercise and Sports Science OR Homeopathy OR Massage OR Musculoskeletal Therapy OR Medicine OR Naturopathy OR Nursing OR Optometry OR Orthoptics OR Orthotics OR Osteopathy OR Pharmacy OR Physiotherapy OR Podiatry OR Psychology OR Radiography OR Social Work
AND
Educat* OR Curricul* OR Teach* OR Learn* OR Competenc*
AND
Informati* OR Comput* OR Online OR Internet OR E-health OR Ehealth OR Tele* OR Electronic OR ICT or IT OR Technology OR Knowledge Management OR Evidence Based*

Medical Informatics Meets Medical Education: the Croatian Experience

Josipa Kern[1], **Kristina Fišter**[1]

[1]University of Zagreb, School of Medicine, Zagreb, Croatia

Abstract

Objectives: The purpose of this paper is to describe the medical informatics program and training at the University of Zagreb, School of Medicine (Croatia).
Methods: We reviewed the medical informatics program, training and research for medical students at the integrated pre-graduate and graduate level, as well as at the postgraduate education and research level.
Results: We present three approaches to teaching and training medical students in medical informatics at the integrated pre-graduate and graduate level. These are (1) Basics of medical informatics taught early in the medical curriculum, (2) Medical informatics which uses students' clinical knowledge and is taught towards the end of the medical curriculum, and (3) individualized research programs. Both Basics of medical informatics and Medical informatics are courses tailored in line with the IMIA Recommendations on Medical Informatics Education for IT users, and adjusted to students' attitudes to medical informatics issues and the position of the courses in the medical curriculum. Postgraduate studies, as the higher level of education at the School of Medicine, also include several mostly elective medical informatics courses dealing with general medical informatics methodology and health information system management in both clinical medicine and public health. Included are also simulation modeling, methods of machine learning and knowledge discovery in medical domains, as well as medical statistics and methods oriented towards free textual data analysis. The postgraduate level includes in addition telemedicine, electrophysiological methods in research, and evidence based medicine.
Conclusions: Medical students are starting to recognize the role of information in their future profession. They require medical informatics applications to support their professional work with patients, as well as their research. In particular they express interest in machine learning, simulation modeling, medical decision making, data security, e-learning, and evaluation of ICT based medical applications.

Keywords

medical informatics, medical students, integrated pre-graduate and graduate medical education, postgraduate medical education

Correspondence to:

Josipa Kern
University of Zagreb, School of Medicine
Address: Rockefellerova 4, 10000 Zagreb, Croatia
E–mail: josipa.kern@snz.hr

EJBI 2011; 7(2):58–63
received: June 17, 2011
accepted: October 3, 2011
published: December 23, 2011

1 Introduction

Medical informatics (MI) has for long been recognized by many authors as a special education subject in the medical curriculum [1, 2, 3, 4, 5, 6, 7]. Sancho et al wrote "our main objectives when planning a MI course were to give students a general overview of the medical applications of computers and instruct them in the use of computers in future medical practice" [2]. Coiera pointed to problem-oriented and careful use of medical records as the important basis for physician's work, however "the problem-oriented medical record is just an information instrument, and clinicians need to know when it is appropriate, and when indeed other formulations might be better choices" [3]. Greenes claims „MI is now appearing on more curricula as a distinct entity" [4]. Shortliffe points to the nature of (bio)medical data, saying „the core issues in the field of MI are those related to the nature of biomedical data and knowledge and their representation and use in computer systems" and, moreover, "from these recurring themes arise a number of research topics in the field", such as experimental planning and verification, data and knowledge acquisition, literature retrieval, diagnosis, treatment planning, human interface, and teaching [5]. Coiera insists on the need that medical students understand "the dynamic and uncertain nature of medical knowledge" [3]. Also, the medical students should be "able to keep personal knowledge and skills up-to-date", to "assess knowledge according to the statistical basis of scientific evidence", "interpret uncertain clinical data and deal with artifact and error", "structure and analyze clinical decisions in terms of risks and benefits", "apply and adapt clinical knowledge to the individual circumstances of patients", "access, assess, select and apply a treatment guideline, adapt it to local circumstances, and communicate and record variations in treatment plan and outcome", "structure and record clinical data in a form appropriate for the immediate clinical task, for communication with colleagues, or for epidemiological purposes", and communicate by using "the most appropriate communication method for a given task" [3].

One recent paper states that the MI as a course of study "requires a firm conviction that practicing medicine in the 21st century demands currency, accuracy, and literacy with the available information sources" [8].

Finally, the literature on medical (biomedical or health) informatics education, as well as the Recommendation given by the International Medical Informatics Association (IMIA) [9], clearly outline the preferred content of MI courses. However, detailed programs with clearly defined lectures, seminars, and practicals should be adjusted to specific course of study (medicine, nursing, etc.) and to previous experience of students in the use of information and communication technology (ICT). Another pertinent question is where in the medical curriculum to position the MI courses: at the beginning (first two years), in the middle or at the end (last two years). An alternative view may be the positioning in the medical curriculum does not much matter.

Another challenge was: what MI subjects should be incorporated in the postgraduate medical education level and how to do it.

The aim of this paper is to describe the long time experience of teaching MI at the School of Medicine, University of Zagreb, for medical students at both the integrated pregraduated and graduate (IPG), as well as postgraduate level of medical education.

2 MI at the IPG Level of Medical Education

Medical curriculum at the IPG level of education at the School of Medicine, University of Zagreb, has included MI courses starting with the year 1970. From 1970 to 2010, MI changed its position in the medical curriculum several times. It started within the third year of study, was shifted several times to other years (first, second, sixth etc.) and in 2010 its position was established at the fifth year of the medical curriculum. The main reason for these shifts could be explained as "nobody was sure what would be the best position of an MI course in the medical curriculum". After discussing the question "what is the best position for MI" with colleagues, and relating to experience of teaching MI subjects at the IPG level, we asked the second and the sixth year students about their opinions related to this problem. Their opinion (63% of the second year students) was that the best position for an MI course would be at the end of the medical curriculum. However, 26% of them suggested the beginning. At the same time, 36% of the sixth year students voted for the end of curriculum, and 43% for the beginning [6, 10].

Additional analyses showed that students with little or no experience in the use of ICT voted for the MI course position at the beginning of the medical curriculum. Therefore, our decision was: MI subjects should be split into basics knowledge, which should be set at the beginning of the curriculum, and more specific, medically oriented knowledge was to be set at the end of the medical curriculum [6, 11]. Consequently, the Basics of informatics course was established as an elective course in the first year of study. Medical informatics was established as a mandatory course in the fifth year of study.

Starting with year 2003, the School of Medicine, University of Zagreb, provides also the MD programs for foreign students, so called the Medical Study in English (MSE) (http://mse.mef.hr/). The MSE students come from a number of countries (Australia, USA, Canada, Malaysia, Portugal, South Africa, UK, Sweden, etc.). Regarding the MI courses, the MSE curriculum is the same as the curriculum for Croatian students, with one exception: the Basics of medical informatics is a mandatory course in MSE.

Both Croatian and English medical IPG programs lead to a Doctor of Medicine degree at the School of Medicine, University of Zagreb.

3 The Aim and Content of MI Courses

The aim of the Basics of medical informatics course is to enable the students to skilfully and competently use ICT, through practicals in the computer laboratory. The course includes basic terminology, Windows operating system, text processing, spreadsheet software, presentation software and browsers, e-mail and nethics, Internet, and searching engines. Wherever possible, medical examples are used in demonstrating ICT use.

The aims of the Medical informatics course (lectures, seminars, and practicals) are: (1) to introduce the students to the concept of MI, as well as develop their skills in working with health data relevant for practice and research in medicine and health care (coding, structuring, databases); (2) to increase awareness of standards, classifications, data protection, and system security, as well as ethics in the use of ICT; (3) to introduce methods of knowledge discovery as well as the concept ICT-based support for medical decision making; (4) to provide insight into real ICT applications for assessing their appropriate-

Table 1: The list of courses with medical informatics subjects.

Course	Course subjects	ECTS
Methods in Medical Informatics	Data structuring and organization; Intelligent data analysis; Simulation modeling; Signal and image processing.	3.5
Information System Management and Clinical Data System	Information system components and infrastructure; Data management; Evaluation of information system.	5
Knowledge Discovery in Medical Domains	Methodology of knowledge discovery; Hypothesis; Noise detecting; Experimental and theoretical verification.	5
Public Health Information System	Public health information needs; Health data sources; Making decision in public health.	3
Textual Statistics	Free text in medicine and health care; Codes, categories, theory; Analysis and interpretation.	5
Electrophysiological methods in medical research	Physiology and electrophysiology; Electrophysiological methods in research; Electro-medical instrumentation – principles and limitations.	4
Telemedicine	Telemedical applications; Standards in telemedicine; Evaluation of applications in telemedicine.	3.5
Statistical Analysis of Medical Data	Statistical methodology; Critical reading scientific and professional papers; Assessment of appropriateness of applied statistical procedures and presentation of results in medical literature.	5.5
Research Methods in Public Health	Operation research methods and tools; Project design and monitoring; Simulation in public health research.	2
Evidence Based Medicine	Basic principles and methodologies; Critical analysis of literature; Advantages and limitations.	3.5

ness/usefulness for a practicing physician; and (5) to develop students' skills needed for searching bibliographic databases and other Internet based sources of medical knowledge.

During the course, special attention is given to seminars where students present and discuss experiences described in professional and scientific papers published mostly in international MI journals. Aiming to assess students' opinions about these papers (what was most challenging for them, what could be or has been applicable in the Croatian health system, what could be most of use, etc.) a survey was conducted [12]. Considering the subject, the papers were grouped as: telemedicine, health information system, ICT versus conventional approach (in communication and research), and medical decision support systems.

Students were asked to rank papers according to their attractiveness and usefulness for medical practice. The results showed that telemedicine was ranked as the most attractive. Health information systems achieved the second place. Decision support was the next attractive topic, especially support systems aiming to avoid medical errors, as well as drug information databases. ICT in communication and research was not considered as very attractive.

Taking into account that both telemedicine and computerization of primary health care were the recent projects in Croatia, the first two ranks could be easily explained. However, attractiveness of decision support system showed that students' expectation of MI could not be neglected. It could be concluded that students are motivated to find out how the ICT applications could support their future medical practice.

Discovering such attractive topics could "open the door" to MI and make it interesting and challenging to medical students. Consequently, students might be expected to become active stakeholders in MI research and practice.

4 MI at the Postgraduate Education Level

Postgraduate level of medical education at the School of Medicine in Zagreb started with MI subjects in year 1966. It was then just short information about computers and their potential role in medicine and health care. Five years later the University Computing Center was established in Zagreb, and students were able to get acquainted with some simple applications, mostly examples of statistical data analysis. More recently, MI is a relevant subject in postgraduate education at the University of Zagreb.

Postgraduate education programs at the School of Medicine have been organized as interdisciplinary Doctoral studies in Biomedicine and Health Sciences, lead-

Table 2: Students' research published from 1994 to 2011. Note: Student's name is in Italic.

Topic	Report of student's research published by himself/herself	with his/her mentor and/or others
Machine learning	*Sonicki Z* (1994) [13] *Vojnić-Zelić D* (1996) [14] *Pikija S* (1998) [15] *Lukačić Z* (1998) [16]	Vuletić S, Kern J, *Sonicki Z*, Ivanković D (1999) [28] *Rimac M*, Kern J (1999) [31] *Lukacić Z*, Kern J, Težak-Benčić M (2000) [26] *Sonicki Z*, Morin A, Plasaj T, Sonicki D, Kusić Z (2000) [29] *Lukacić Z*, Kern J (2002) [27] *Sonicki Z*, Gamberger D, Šmuc T, Sonicki D, Kern J (2002) [30]
Data security	*Markota M* (1999) [17]	*Markota M*, Raič G (1997) [32] *Markota M*, Kern J, Švab I (2001) [33]
E-learning	*Fišter K* (2000) [18] *Marinović D* (2009) [19]	*Marinović D*, Hren D, Sambunjak D, Rašić I, Škegro I, Marušić A, Marušić M (2009) [34]
Simulation modeling	*Božikov J* (1997) [20] *Rimac M* (2002) [21] *Manestar-Blažić T* (2005) [22] *Poljičanin T* (2010) [23]	*Manestar-Blažić T*, Božikov J (2004) [36] *Rimac M*, Božikov J (2007) [35] *Manestar-Blažić T*, Božikov J (2007) [37]
Decision making in health organization	*Ilakovac V* (1996) [24] *Piberl S* (2011) [25]	*Ilakovac V*, Kern J (1994) [38]
Evaluation studies in medical informatics		*Andrijašević L*, *Angebrandt P*, Kern J (2010) [39]
Biostatistcs	*Smoljanović L* (1994) [40] *Kujundžić M* (1995) [41] *Kujundžić Tiljak M* (2000) [42] *Šimurina T* (2011) [43]	*Kujundžić Tiljak M*, Kern J, Ivanković D, Tiljak H, Vuletić S (2001) [44]
Free text analysis	*Fišter K* (2000) [45] *Hercigonja-Szekeres M* (2010) [46]	*Hercigonja-Szekeres M*, *Marinović D*, Kern J (2009) [47]

ing to PhD degree and several professional studies such as Anaesthesiology, Cytology, Diabetology, Epidemiology, Microbiology, Occupational Health, Paediatrics, Public Health, etc., being mostly parts of medical specialization programs.

Some of the professional studies, for example Public Health, Occupational Medicine, and School Medicine, include certain MI subjects, but most of MI issues are subjects of interdisciplinary Doctoral studies. List of courses at the Doctoral study consists of 140 courses, which are either mandatory or elective. Ten of them are related to MI subjects. All but one of MI courses belong to elective group. All of them should be considered as independent, and students can choose one or more of MI courses according to their wishes.

The list of courses related to MI is shown in Table 1.

Statistical Analysis of Medical Data is the only mandatory course in this list. Other courses are usually elected by 5 to 10 students per year (of 50 to 60 enrolled). So far evaluation was undertaken only for the mandatory course and used for course improvement.

4.1 Students' Research

Individual program research at the School of Medicine was adjusted to students willing to get more knowledge in MI. It could be practicing at both, IPG and postgraduate level of medical education. Individual student research should finish with a paper or a poster, a master thesis, or a dissertation. Many students do congress or journal papers with their mentors, sometimes as preliminary results of their research, sometimes as a final result. Students' research published from 1994 to 2011 is shown in Table 2.

5 Discussion

There is no doubt that ICT is entering into medicine and health care. Effect of computerization the clinical settings is well documented [48, 49, 50]. Benefits of decision support system are remarkable even if just electronically available guidelines were used as support [51, 52, 53, 54, 55, 56].

On the other side, the ICT based medical or health care applications could not be imagined without cooperation of medical profession. Therefore medical professionals should be educated for coming technologies, for changes in their work, for management of changes and management of knowledge.

Several surveys on medical informatics as a discipline, on attitudes of students and medical professionals to this discipline showed to be positive. Some exceptions, like survey on electronic problem lists which showed great variability in attitudes of health professionals [57]. However, this result just reflects situation where health professionals were not enough educated or there were not enough co-operations with ICT professionals who use to develop application.

The Croatian experience in medical informatics education programs for medical students based not only to poll, showed positive results. Namely, number of students doing their own research, their student papers, master's and doctoral thesis are the real evidence that medical informatics for medical students were not a missed action.

6 Conclusion

The medical students recognize the role of information in their future profession. They feel the medical informatics methods as useful in their professional work (with patients) as well as in research. The special emphasize of their interest is in searching for professional and scientific information, and decision support systems related to medicine and health care.

References

[1] Hasman A.: Description of Blockcourse in Medical Informatics. Methods Inf Med 1989; 28(4), pp. 239-242.

[2] Shortliffe E.: Medical Informatics meets medical education. Medical Technology. SMR 1999; 1(1), pp. 1-3.

[3] Greenes R.A., Shortliffe E.H.: Medical informatics -– an emerging academic discipline and institutional priority. JAMA 1990; 263, pp. 1114-1120.

[4] Sancho J.J., Gonzalez J.C., Patak A., Sanz F., Sitges-Serra A.: Introducing medical students to medical informatics. Medical Education 1993; 27(6), pp.479-483.

[5] Coierra E.: Medical informatics meets medical education. MJA 1998; 168, pp. 319-320.

[6] Kern J.: Medical Informatics Education -– How to Tailor the Course to Given Stage of Student's Knowledge? AIM 2002; 10, pp. 59-61.

[7] Berner E.S., Boulware D.W. :Medical Informatics for Medical Students: Not Just Because It's There. MEO 1996;1, p. 3.

[8] Schwarz B.: The Introduction of a Medical Informatics Course into a Medical School Curriculum. Medical Reference Services Quarterly 2011;30(1), pp. 74-82.

[9] Mantas J., Ammenwerth E., Demiris G., Hasman A., Haux R., Hersh W., Hovenga E., Lun K.C., Marin H., Martin-Sanchez F., Wright G.; IMIA Recommendations on Education Task Force: Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision. Methods Inf Med. 2010;49(2), pp.105-120.

[10] Kern J.: Medical informatics in the medical curriculum–when? Stud Health Technol Inform 1999;68, pp. 484-488.

[11] Kern J.: Health and medical informatics in Croatia. Health Info Libr J. 2008;25(4) pp. 302-308.

[12] Kern J, Fišter K, Polašek O, Sović S, Božikov J. What the medical informatics topics are considered as attractive to sixth year students of medicine. Medicinska informatika 2009;9, pp.92-100.

[13] Sonicki Z.: Inductive learning methods in medical decision making and prediction. Zagreb: University of Zagreb, School of Medicine 1994 [Master's thesis].

[14] Vojnić-Zelić D. Parsimonian analytical model for diagnosing knee joint arthrosis. Zagreb: University of Zagreb, School of Medicine 1996 [Master's thesis].

[15] Pikija S.: APGAR prediction based on prenatal data – neural network methodology. Zagreb: University of Zagreb, School of Medicine 1998 [Student's paper].

[16] Lukačić Z.: Fuzzy logic based expert system for prediction in medicine. Zagreb: University of Zagreb, School of Medicine 1998 [Master's thesis].

[17] Markota M.: Data protection in health information system. University of Zagreb, School of Medicine 1999 [Master's thesis].

[18] Fišter K.: A Medical Student for Fellow Medical Students: How We Can Use the Internet to Learn that One Bit More and Have Fun at the Same Time. Poster at the MIE 2000, Hannover 2000 [The best poster of the Congress].

[19] Marinović D.: Attitudes of medical students to ICT in learning the medicine. Zagreb: University of Zagreb, School of Medicine 2009 [Master's thesis].

[20] Božikov J.: Reflection of multistage carcinogenesis model on cancer incidence in human population - example of colorectal cancer. Zagreb: University of Zagreb, School of Medicine 1997 [Doctoral thesis].

[21] Rimac M.: Dynamic simulation model of the cerebral cortex neurogenesis. Zagreb: University of Zagreb, School of Medicine 2002 [Master's thesis].

[22] Manestar-Blažić T. :A simulation model of telomere influence on the development and growth of cancer - testicular seminoma and nonseminoma example. Zagreb: University of Zagreb, School of Medicine 2005 [Master's thesis].

[23] Poljičanin T.: Role of CroDiab registry in prevention of complications in diabetics patients. Zagreb: University of Zagreb, School of Medicine 2010 [Doctoral thesis].

[24] Ilakovac V.: Model of decision support in a hospital. Zagreb: University of Zagreb, School of Medicine 1996 [Master's thesis].

[25] Piberl S.: Mobile ICT in pre-hospital unit of emergency medicine in Health centre Murska Sobota. Zagreb: University of Zagreb, School of Medicine 2011 [Master's thesis].

[26] Lukačić Z., Kern J., Težak-Benčić M.: Detecting predictors of new-born survival by fuzzy sets based machine learning system. Stud Health Technol Inform 2000;77, pp.795-798.

[27] Lukačić Z., Kern J.: Consistency and reproducibility of attribute extraction by different machine learning systems. Stud Health Technol Inform 2002;90, pp. 316-319.

[28] Vuletić S., Kern J., Sonicki Z., Ivanković D.: Possibilities of See5 software in forecasting of life expectancy not achieving. Stud Health Technol Inform 1999;68, pp.696-699.

[29] Sonicki Z., Morin A., Plasaj T., Sonicki D., Kusić Z.: Redundant thyroid laboratory diagnostic modules in laboratory information system–a way to improve the performance. Stud Health Technol Inform 2000;77, pp. 842-846.

[30] Sonicki Z., Gamberger D., Šmuc T., Sonicki D., Kern J.: Dana mining server - on-line knowledge induction tool. Stud Health Technol Inform 2002;90, pp. 330-334.

[31] Rimac M, Kern J. Prognosis for life expectancy using the inductive learning method. Lijec Vjesn. 1999 ;121(1-2), pp.18-21.

[32] Markota M., Raič G.: Implementing data privacy and security (the Slovenian experience). Stud Health Technol Inform 1997;43, pp. 879-883.

[33] Markota M., Kern J., Švab I.: Attitudes towards information system security among physicians in Croatia. Methods Inf Med 200;40(3), pp. 221-224.

[34] Marinović D., Hren D., Sambunjak D., Rašić I., Škegro I., Marušić A., Marušić M.: Transition from longitudinal to block structure of preclinical courses: outcomes and experiences. Croat Med J 2009;50(5), pp.492-506.

[35] Rimac M., Božikov J.: Neurogenesis: from experimental dana to system dynamics model. In: Proceedings of the 6th EUROSIM Congress on Modelling and Simulation (Eds. Zupančič B., Karba R., Blažič S.), Vol. 2: Full Papers. Ljubljana, 2007. /CD-ROM/ Ljubljana: EUROSIM/SLOSIM, 2007. Contribution 624,pp.1-8.

[36] Manestar-Blažić T., Božikov J.: A simulation model of the testicular carcinogenesis. In: Proceedings of the 5th EUROSIM Congress on Modeling and Simulation (Eds. Hamam Y., Attiya G.), Paris, Marne la Vallée, 2004. /CD-ROM/ Paris: EuroSim, 2004.

[37] Manestar-Blažic T., Božikov J.: A simulation of the formation of melanocytic nevi. In: Proceedings of the 6th EUROSIM Congress on Modelling and Simulation (Eds. Zupancic B., Karba R., Blažic S.), Vol. 2: Full Papers. Ljubljana, 2007. /CD-ROM/ Ljubljana: EUROSIM/SLOSIM, 2007. Contribution 568, pp.1-7.

[38] Ilakovac V., Kern J.: An Analysis of the Length of Stay in Hospitals. In: Ceric V, Hljuz-Dobric V(Eds.) In: Proceedings ITI'94, Pula 1994, pp. 423-428.

[39] Andrijašević L., Angebrandt P., Kern J.: Computerization of family practice evaluated by physician. In: Book of Abstracts of the 2nd Croatian Congress on Preventive Medicine and Health Promotion, October 13-16 ,2010, Zagreb, Croatia, pp.195-196.

[40] Smoljanović L. Similarity measures of parents and children quantitative characteristics, Zagreb: University of Zagreb, School of Medicine 1994 [Master's thesis].

[41] Kujundžić M. Genealogical model of epidemiological dana analysis, Zagreb: University of Zagreb, School of Medcicine 1995 [Master's thesis].

[42] Kujundžić Tiljak M. Genealogical structuring of population and estimation of mortality, Zagreb: University of Zagreb, School of Medicine 2000 [Doctoral thesis].

[43] Šimurina T. Predictive model for postoperative vomiting in patients undergoing general anestesia for laparoscopic gynecological surgery. Zagreb:University of Zagreb, School of Medicine 2011 [Doctoral thesis].

[44] Kujundžić Tiljak M, Kern J, Ivanković D, Tiljak H, Vuletić S. Genealogical structuring of a population. Coll Antropol. 2001;25(1), pp.127-40.

[45] Fišter K. Free text analysis. Zagreb: University of Zagreb, School of Medicine 2000. [Student's paper. Rector's award].

[46] Hercigonja-Szekeres M. Value of textual data in observational epidemiological research. Zagreb: University of Zagreb, School of Medicine 2010. [Doctoral thesis].

[47] Hercigonja-Szekeres M, Marinović D, Kern J. Computer laboratory in medical education for medical students. Stud Health Technol Inform. 2009;150, pp.926-30.

[48] Garg A.X., Adhikari N.K., McDonald H., Rosas-Arellano M.P., Devereaux P.J., Beyene J., Sam J., Haynes R.B.: Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA 2005; 293(10), pp.1223-1238. Review.

[49] Chaudhry B., Wang J., Wu S., Maglione M., Mojica W., Roth E., Morton S.C., Shekelle P.G.: Systematic review: impact of health information technology on quality,efficiency, and costs of medical care. Ann Intern Med 2006;144(10), pp.742-752. Review.

[50] Hersh W.R., Hickam D.H., Severance S.M., Dana T.L., Krages K.P., Helfand M.: Telemedicine for the medicare population: update. Evid Rep Technol Assess (Full Rep) 2006;131, pp.1-41. Review.

[51] Latoszek-Berendsen A., Tange H., van den Herik H.J., Hasman A.: From clinical practice guidelines to computer-interpretable guidelines. A literature overview. Methods Inf Med 2010;49(6), pp.550-70. Review.

[52] van Engen-Verheul M,. de Keizer N., Hellemans I., Kraaijenhagen R., Hasman A., Peek N.: Design of a continuous multifaceted guideline-implementation strategy based on computerized decision support. Stud Health Technol Inform 2010;160, pp. 836-40.

[53] Goud R., Hasman A., Strijbis A.M., Peek N.: A parallel guideline development and formalization strategy to improve the quality of clinical practice guidelines. Int J Med Inform 2009;78(8), pp. 513-20.

[54] De Clercq P., Kaiser K., Hasman A.:Computer-Interpretable Guideline formalisms. Stud Health Technol Inform 2008;139, pp.22-43.

[55] Goud R., Hasman A., Peek N.: Development of a guidelinebased decision support system with explanation facilities for outpatient therapy. Comput Methods Programs Biomed 2008;91(2), pp.145-153.

[56] Goud R., Jaspers M.W., Hasman A., Peek N.: Subjective usability of the CARDSS guideline-based decision support system. Stud Health Technol Inform 2008;136, pp.193-198.

[57] Wright A., Maloney F.L., Feblowitz J.C.: Clinician Attitudes Toward and Use of Electronic Problem Lists: A Thematic Analysis. BMC Medical Informatics and Decision Making 2011; 11, p. 36 (available at: http://www.biomedcentral.com/1472-6947/11/36)

Education, Research and Professionalism in Health and Biomedical Informatics: Myths, Realities and Proposals for the Future

Fernando Martin-Sanchez[1], **Kathleen Gray**[1]

[1]Health and Biomedical Informatics Research Unit, Faculty of Medicine, Dentistry and Health Sciences and Department of Information Systems, The University of Melbourne, Australia

Abstract

This article proposes a definition of the field of Health and Biomedical Informatics, in line with recent international developments. According to the authors, there are several myths or misconception concerning the future development of this scientific and professional discipline. We describe the current situation of Health and Biomedical Informatics at an international level, include specific analysis for the two countries where the authors have worked (Spain and Australia) and finally propose a series of recommendations to improve it. All this analysis is carried out in three areas: education, research, and professionalism (characterisation and development of the profession). Defining the body of knowledge of the discipline itself is an initial step that must be made and taken as soon as possible.

Keywords

Education, research, professionalism, biomedical informatics, health informatics

Correspondence to:

Fernando Martin-Sanchez
The University of Melbourne
Address: Level 1, 202 Berkeley Street. 3010 VIC., Australia
E–mail: fjms@unimelb.edu.au

EJBI 2011; 7(2):64–71
received: July 28, 2011
accepted: October 7, 2011
published: December 23, 2011

1 Introduction

Biomedical and Health Informatics (BMHI)[1] has been defined as "the scientific field that deals with biomedical information, data and knowledge – their storage, retrieval and optimal use for problem solving and decision making [1]."

Other definitions as in [2, 3, 4] and [5] emphasize even more the optimal use of information in the domain of biomedicine. For these authors, and this would be the approach taken in this text, informatics is the science of information. Information is defined as "data + meaning". Thus, biomedical informatics would be information science applied or studied in the context of biomedicine.

In several places, some people tend to associate the term "informatics" with any activity at any level that is related to the use of computers. In our opinion, this very general sense devalues the academic discipline and hinders the recognition of its professionals. Clearly defining Health and Biomedical Informatics is an essential step to allow progress on practical issues such as: education, research, development of a professional career or consolidating an international community.

A key feature of this definition is that if we accept that biomedical informaticians study biomedical information (data and its meaning), then, professionals of this discipline should understand the context or biomedical domain (biology, medicine, pharmacy, nursing . . .). This is because in this area the relevant concepts (eg a gene, fibrosis) are very difficult to relate with formal representations. Bernstam et al. uses the example of a Bank to support this idea. In this domain, the "semantic gap" between the data (numbers) and associated information (account balances) is very limited, i.e. there is a fairly direct relationship between data and information. In biomedicine, on the contrary, this "semantic gap" is very pronounced. Biomedical data are not often directly associated with a concept and the complexity of human beings and the pro-

[1]We are taking this name because it has been used in the recently published article for educational recommendations from IMIA (International Medical Informatics Association). Reference: [6]

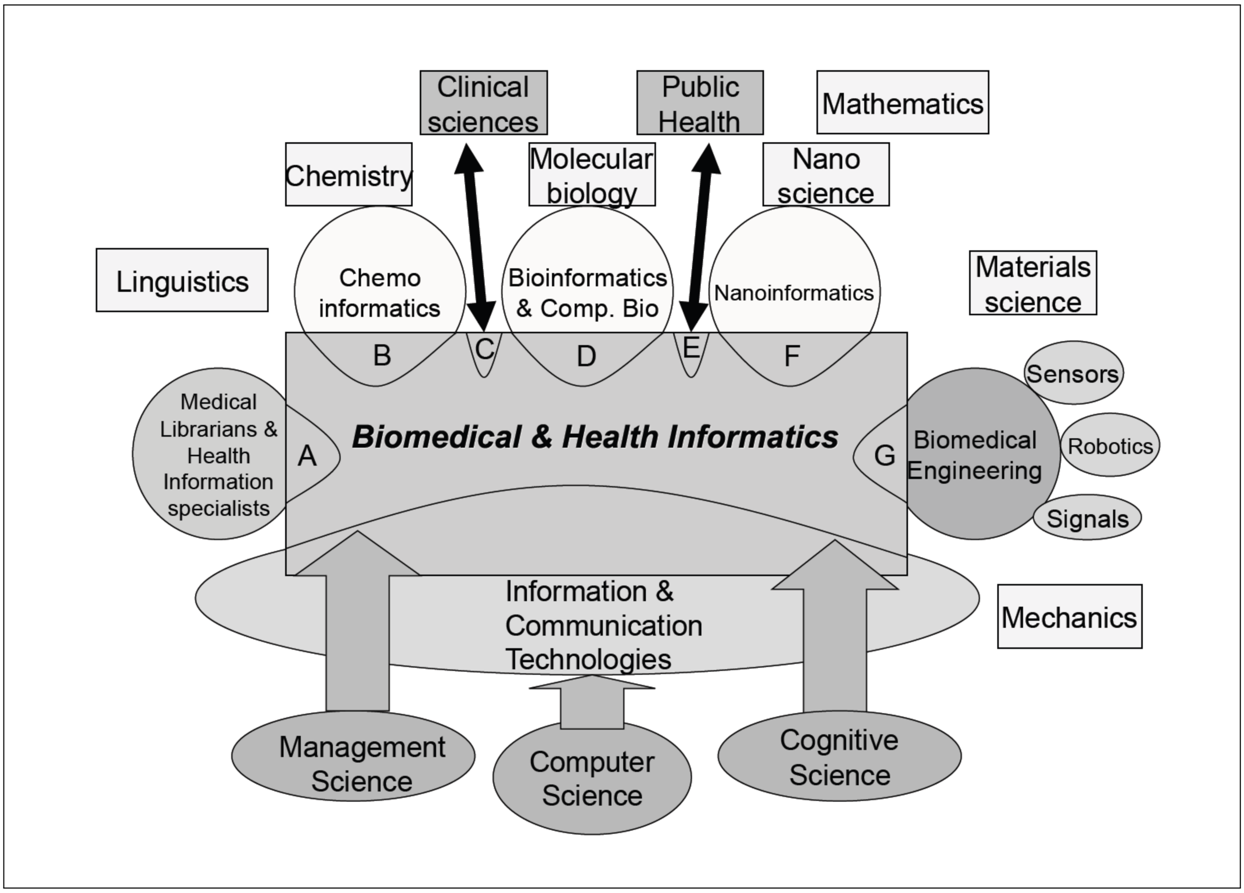

Figure 1: Disciplines overlapping with BMHI: A - Medical Information Science, B - Medical Chemoinformatics C – Medical (Clinical) informatics, D - Medical (translational) Bioinformatics, E - Public Health Informatics, F - Medical Nanoinformatics G - Devices and medical image processing.

cesses involved in biomedicine are not easily reducible to computer systems and conventional data processing. According to [2], humans can be considered as "systems" that have developed by evolution, and this makes its subsystems (organs) difficult to separate. This makes two individuals react differently to the same events (a drug), as opposed to other systems, like an airplane. Although very complex, airplanes respond to a design, so the parts are separable and respond equivalently to the environment.

This definition allows BMHI to be distinguished from other sometimes overlapping disciplines. Biomedical engineering, for example, tries to solve biomedical problems using engineering methods. Although these solutions may include, in some cases, the development of computer programs, the focus is on the problem to be solved, and not on specific aspects of data representation or information processing.

It is true that health and biomedical informatics do not yet have their own professional identity. The field is very heterogeneous. The same can be said of the profiles of people working in this field. It is also a multidisciplinary field with multiple areas of overlap with other disciplines, as shown in Figure 1, originally published in the educational recommendations of IMIA [7].

However, there is a body of knowledge in the BMHI discipline itself, which must be known to practitioners. Defining this body of knowledge can contribute to the establishment of educational programs at various levels (Master, PhD) to train the future professionals. It is also necessary to know in order to undertake tasks and participate in and promote innovative research projects. Finally, it would advance the professionalism, understood as the development of a profession with its own entrance requirements, competencies, certification, code of ethics or professional career. This idea is graphically represented in Figure 2.

Although it is not the aim of this paper and is beyond its scope to develop, an indication of the body of knowledge characteristics of BMHI should be provided. Since the emphasis is on data processing and on the generation of meaning in the domain of biomedicine, the key aspects to consider are related to the design and development of theories, models and methods to solve problems related to information architecture, retrieval, performance or analysis. Obviously, with the progress of the different health technologies (imaging, laboratory, medical records) in recent decades, the amount of data to handle is so large that Information and Communication Technology plays an important role in supporting these processes of information. We must emphasize again that it is the information and not the underlying technologies which represent the primary focus of BMHI.

Returning to the body of knowledge characteristic of BMHI, its aim is knowing what information is needed and how it can be managed to solve a particular problem in biomedicine. From this perspective, all aspects of databases (to store and retrieve data), algorithms (data processing), artificial intelligence (to generate meaning from data and existing data), ontologies (to represent and integrate data), visualization techniques (presenting data and information generated) or aspects of usability (human factors relevant to access to information) clearly represent core components of the body of knowledge and abilities of BMHI. In the biomedical context, this can be related to digital health records, clinical documentation, decision making support, interpretation of medical images and signals, etc. It is also important to study the history of the discipline, which dates back to more than 60 years; the successes and failures, their schools of thought, institutions, and main experts and leaders in the field. Only from the study of these can we avoid "reinventing the wheel" and making mistakes that have been previously made. We will be able to follow the experience of "success stories" and the methods that have proven useful in the international context.

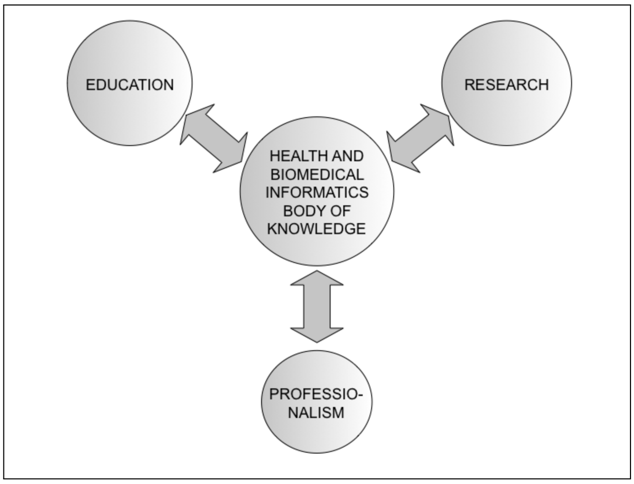

Figure 2: The definition of BMHI body of knowledge can advance issues related to education, research and development of the profession.

Some authors have even proposed sub-disciplines within BMHI. This depends on the specific domain in which data is handled and its meaning. For instance, bioinformatics (data from molecular and cellular level) [8], medical Imaging (tissues and organs level), clinical or medical Informatics (patients individual data), public health informatics (population-level data) [9] or the nascent nanoinformatics (submolecular or atomic level). Some BMHI education programs are based on this definition [10, 11].

2 Myths in Research and Education in Health and Biomedical Informatics

A myth is defined as "a set of beliefs and idealized images that are formed around a phenomenon and become a model or prototype". When analyzing the status of Education and Research in BMHI, and compared with the situation in other fields, there are clear differences and it is likely that the following myths or misconceptions are at the basis of some existing problems. Below, we discuss these myths, which, though seemingly innocent, are hindering the development of the discipline and thus should be discussed and answered.

Myth 1. Health and Biomedical Informatics is just the community resulting from the sum of the informaticians, plus physicians, plus pharmacists, plus nurses, plus other health professionals…

This idea denies the existence and the need to know the specific body of knowledge of the BMHI discipline itself. A corollary of this myth would be then that specific *education* in the area would not be needed. However, it is well established in many countries that a professional group trained specifically in BMHI is increasingly necessary, although there are different training routes to access this education.

Myth 2. Health and Biomedical Informatics does not involve research, it is just developing or adapting tools.

This way of thinking hinders the consideration of BMHI as a scientific discipline. There is a tendency for those responsible for implementing systems in health centers to regard all information systems as "commodities" that can simply be bought off the market and implemented. This may be true in some cases of hardware or communications systems, but systems should be much closer to the specific needs of a clinical service or a Research Unit. This myth also represents a barrier to the development of *research* projects by experts in BMHI. This requires innovative solutions to be explored, and collaboration with clinicians and biomedical researchers.

Myth 3. Developing information technology projects in this environment is similar to other fields of activity (banking, insurance,…)

By this criterion, any informatician, without experience in the biomedical and health domain, would be able to direct and lead BMHI projects. This myth, in our opinion, is at the basis of some of the projects that have not succeeded. This is due to a lack of understanding and communication difficulties between informaticians and clinicians. The *development of the profession* of BMHI would accredit professionals who have the skills to lead these projects, with specific knowledge domain and ability to communicate effectively with both technologists and the clinicians.

So we could summarize our common position against these myths as it follows: BMHI is informatics, as such, BMHI needs the knowledge of informatics. But also since it is applied to health and biomedicine its practitioners should have a good knowledge of the concepts that apply to biomedicine and also about the organization of healthcare. Research in this field enriches the specific body of knowledge of the discipline and contributes to advance innovation in response to specific needs. Without knowledge of and experience in biomedicine informaticians may fail in BMHI projects.

3 Current Status of Health and Biomedical Informatics internationally

3.1 Education

A thorough review of the many educational programs that are provided internationally at different levels (undergraduate, postgraduate, continuing medical education) is required. This section highlights some references that should be taken into account.

With regards to the education of professionals in BMHI, it must be stated that the National Institutes of Health (NIH) of USA are financing, for more than 20 years, different graduate programs (Master and PhD) in Biomedical Informatics. These programs are offered at the most prestigious universities across the country (the number can vary from year to year, but usually close to 20). Similar programs exist in Germany, UK, Ireland, Canada and Norway, among others. It must also be pointed out that the Hospital Italiano de Buenos Aires (HIBA), has a program of residency in Biomedical Informatics.

The U.S. Department of Health has recently awarded grants totaling $144 million U.S. for training human resources and research in Health Informatics. This program is included in the framework of the "American Recovery and Reinvestment Act" (ARRA), which spend U.S. $2,000 million to promote the meaningful use of digital patient medical records in the U.S. Of these 144 million, 84 million was allocated to universities and consortia of "colleges" with the goal of training 50,000 new professionals in health informatics in the coming years.

There are also many examples in which undergraduate education of health professionals (e.g. medicine) includes a core subject and linking one or more subjects with BMHI. The aim is to equip the future health with the skills for basic biomedical information management [12].

Regarding Continuing Education in Informatics, health professionals should give importance to the AMIA 10x10 program of the American Medical Informatics Association[2], which aims to train 10,000 people through mixed courses (face-on line) about 10 weeks duration and are taught in collaboration with leading universities and hospitals in the U.S. [13, 14]. HIBA has developed a Spanish version of the course AMIA 10x10, at the University of Oregon, and has already run it several times with great success [15].

3.2 Research

The European Commission, through its Programme - ICT for Health has been funding research in areas related to BMHI for over 20 years. The V Framework Programme (2001) began to define a specific area known as BMHI, which has had its development in the Sixth Framework Programme (2003-2007), mobilizing more than 100 million Euros. Currently, during the Seventh Framework Programme, the projects included in the VPH Program (Virtual Physiological Human) continue to develop aspects of biomedical informatics.

In the U.S., the NIH Roadmap, which marks its priority areas of research includes computational biomedicine and the programs developed by the NIH included the creation of 7 NCBCs (National Centers for Biomedical Computing) and 60 CTSA (Clinical and Translational Research Awards). The former are engaged in research in BMHI, while the latter are entities that perform clinical trials, but must include at least one group with expertise in BMHI.

Of the $144 million provided for the Health Informatics program by the U.S., government via the ARR Act, 60 million was allocated to four research projects that address strategic issues for the development of this area: security, decision support decisions of patients and clinicians, secondary use of medical records and network infrastructure and application architectures.

3.3 Professionalism

In addition to the significant efforts being undertaken by the British National Health Service (NHS) and other scientific societies, such as COACH (Canada Health Informatics Association)[16] to advance the characterization of the profession of BMHI and the establishment of a career, with different access requirements and promotion, we should also point out here the recent advances achieved by AMIA for the standardization of educational programs and professional certification. AMIA has now been accepted in the Council of Medical Societies of America and is currently immersed in an ambitious project to

[2] American Medical Informatics Association. AMIA 10x10 program. Available at: http://www.amia.org /education /10x10-courses. Date Accessed: June 2011

ensure that clinical informatics is recognized as a medical subspecialty, which could be accessed from any major medical specialty. The specialty which has agreed to pilot the process is the one on Preventive Medicine and Public Health. AMIA estimates that the project will be completed by 2013, including the creation of a "Council" of examiners who will certify the adequacy of educational programs and two access routes to the subspecialty based professional practice or in education [17].

4 Current Situation of Education and Research in Health and Biomedical Informatics in Spain

4.1 Education

The situation can clearly be improved. At present, the university is not generating the profile of graduates required by companies and institutions in the sector. At the graduate level, very few educational programs are related to BMHI. There are some studies that offer a Master in Bioinformatics or in Biomedical Engineering, but not with the BMHI approach explained in the introduction of this article.

At the undergraduate level the study recently carried out by the COMBIOMED Research Network (http://combiomed.isciii.es) and the Spanish Health Informatics Society (http://www.seis.es) showed that there are enormous needs at the Spanish medical schools (including those newly created) in terms of training future doctors in skills and knowledge for managing information. Core subjects hardly exist in BMHI and in some cases, if offered, are optional, and deliver content on very basic office applications and literature searches. There are some honorable exceptions, such as in Barcelona. Universities like UB or UPF include core subjects of BMHI in the degree program. However, it is especially worrying that most new medical schools do not adequately address these needs, which have been recognized by both the White Paper of Medicine, coordinated by ANECA, and the leading international associations of medical education [12].

With regard to the third domain of education in BMHI, the continuous education of professionals, the situation is not very positive. There are few on-line training programs and very few initiatives of classroom training.

4.2 Research

The situation in Spain with regards to research on BMHI, measured in terms of classical, internationally accepted indicators (number of communications to international conferences, number of publications in peer-reviewed scientific journals, return on research projects funded by the Commission Union), could be defined as paradoxical. This adjective refers to the fact that there are very few groups (low quantity), although they are very competitive at an international level (high quality). One might therefore ask whether the level reached in the international arena is due to personal efforts rather than well-founded political support. One might also ask what the sustainability of these few groups with international projection is.

Another worrying indicator is the fact that Spain is one of the few countries in Europe that has not hosted any major international conference in BMHI (MEDINFO or MIE).

Finally, we must say that the involvement of IT staff from Spanish medical centers in research projects and presenting results at conferences or international journals is almost anecdotal, again with some honorable exceptions such as, Coruna or Granada.

4.3 Professionalism

Practically no steps have been taken towards the recognition of the profession of BMHI in Spain. A generally well-informed discussion on these points has not yet taken place. Currently we can only mention the actions by some regional health services, involving the creation of specific professional scales (at various levels).

5 Current Situation of Education and Research in Health and Biomedical Informatics in Australia

5.1 Education

In the past decade, the trend has been for Australian undergraduate and postgraduate health informatics degrees to close due to lack of demand. Currently there are around 10 university providers of BMHI degrees, including majors in information technology or information systems degrees [18]. In addition, diverse elective subjects are offered in a number of undergraduate and postgraduate degrees in ICT and in health sciences at many universities; this activity is very changeable and efforts to map it are difficult. Offering short courses for continuing professional development is increasingly of interest to professional associations and Registered Training Organisations (RTOs), both public and private, in the vocational education and training (VET) sector. International providers are able to meet the needs of some Australians, either through intensive programs requiring block attendance offshore, or through open and distance learning.

Some clinical health professional organisations in Australia have developed competency statements for general practice [19] and nursing [20], for example – although it is not clear how these are being implemented or audited in accredited curricula. A national project funded by the Australian Learning and Teaching Council is encouraging the development of ehealth capability in students who are enrolled in entry-level clinical health professional degrees: http://clinicalinformaticseducation.pbworks.com.

There is as yet no Australian national framework for accrediting health informatics curricula. However a national Australasian Health Informatics Education Council [21] has been formed to advance this, under the auspices of the Australasian College of Health Informatics (ACHI), the Health Informatics Society of Australia (HISA), Health Level 7 (HL7) Australia, the Health Information Management Association of Australia (HIMAA) and the Australian Computer Society (ACS), with Commonwealth government observers.

5.2 Research

The Commonwealth government research body CSIRO supports the Australian eHealth Research Centre [22]. Several Australian universities have academic research units in health informatics and related fields, for example:

- Bond University http://www.bond.edu.au/research/research-at-bond/university-research-centres/centre-for-health-informatics/
- Deakin University http://www.deakin.edu.au/buslaw/infosys/research/healthinfo/
- Edith Cowan University http://www.ecu.edu.au/faculties/computing-health-and-science/research-activity/research-centres/ehealth-research-group
- Monash University http://www.mihsr.monash.org/e-health/
- University of Melbourne http://www .healthinformatics.unimelb.edu.au/
- University of New South Wales http://www.chi.unsw.edu.au/
- University of Queensland http://www.uq.edu.au/coh/

A study of Australian health informatics publications in PubMed 1970-2005 showed a consistent increase in line with world trends [23]. National competitive grant funding for health informatics research in Australia has increased from $300 000 to $8 million during the period 2000-2010 [24].

5.3 Professionalism

A recent study of the Australian health informatics workforce [25] concluded that there are over 10,000 people in this workforce now, many with non-formal education or none in health informatics, and that this number represents a workforce shortage in some settings and a prospective shortfall in others. Concerns about the supply of expert informaticians are becoming more acute as Australia proceeds to implement system-wide health and ehealth reforms nationally [26, 27].

The only national process for gaining professional credentials as a health informatician is to apply for full membership or fellowship of the Australasian College of Health Informatics [28].

6 Proposals for the Development of Education and Research in Biomedical Informatics and Health

6.1 Education

As we have seen, we can distinguish at least three different levels with regard to education in Health and Biomedical Informatics. Each of them should initiate efforts to better prepare current and future professionals:

- Knowledge of biomedical informatics, needs to spread and be explained to to all the medical schools and other health careers.
- Training Specialists in Biomedical Informatics (graduate programs such as Masters, Ph.D., Residency). It should follow the recommendations published by IMIA (International Medical Informatics Association).
- Continuing Medical Education of professionals. It could be done adapting the AMIA 10x10 program model of the American Medical Informatics Association)

Also we should pay special attention to innovative teaching methods that are being applied successfully in this field such as workshops, summer schools, online resources, Web 2.0, multidisciplinary working groups, problem-solving oriented training [29, 30, 31].

6.2 Research

Some actions that could be considered are:

- Designing training modules and specific research methodology for professional BMHI.
- Urging more attention to be paid to this discipline by research funding agencies, trying to ensure their presence in the Research & Development plans.
- Creating awareness in CIOs of hospitals on the importance of leading activities and participating in research projects.

6.3 Professionalism

To follow the path already undertaken by British or American colleagues, it would be necessary to create a working group to analyze the possibility of Biomedical and Health Informatics being recognised as a profession. You might even think of creating a model program RMI "Resident Medical Informatician." This involves talks with the ministries of health and education and contacts with the Board of Medical Specialties. However, the road to be traveled to make this a feasible possibility is very long. To cite one example, AMIA has had to demonstrate to the Board of Medical Specialties U.S. that they could meet a number of requirements for assessing the application. Among them were: having a code of ethics, having a body of peer-reviewed scientific communication (the magazine JAMIA), educational programs, rules, definitions of competencies, establishing a Scientific Society (AMIA) that runs annual meetings catering to a professional population of sufficient size and have an "Academy" ("American College of Medical Informatics").

7 Disclaimer

The opinions expressed in this article are the sole responsibility of their authors and should not be associated with the institutions with which they are linked.

This article is based on a previous article published in 2010 in I+S, the Journal of SEIS (Spanish Health Informatics Society).

Acknowledgements

The authors wish to acknowledge their colleague, Ambica Dattakumar, who reviewed the English translation of the original paper in Spanish.

References

[1] Shortliffe EH y Cimino J, "Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Health Informatics)", (2006). Ed. Springer.

[2] Bernstam EV, Smith JW, Johnson TE. (2010) "What is Biomedical Informatics". Journal of Biomedical Informatics; 43 104-110.

[3] Haux R. (1997) “Aims and tasks of medical informatics. International Journal of Medical Informatics 44 (1): 9-20.

[4] Zvarova J. (1997) “On the medical informatics structure”. International Journal of Medical Informatics 44 (1): 75-81.

[5] Hersh W. (2009). "A Stimulus to define Informatics and Health Information Technology". BMC Medical Informatics and Decision Making. 9:24.

[6] Mantas J, Ammenwerth E, Demiris G, Hasman A, Haux R, Hersh W, Hovenga E, Lun KC, Marin H, Martin-Sanchez F, Wright G; (2010) IMIA Recommendations on Education Task Force. "Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics. First Revision". Methods Inf Med. Jan 7;49(2):105-120.

[7] Martin-Sanchez F, Maojo V, Lopez-Campos G. (2002) "Integrating genomics into health information systems". Methods Inf Med.;41(1):25-30.

[8] Kukafka R, O’Carroll PW, Gerberding JL, Shortliffe EH, Aliferis C, Lumpkin JR, Yasnoff WA. (2001) "Issues and opportunities in public health informatics: a panel discussion". J Public Health Manag Pract; 7 (6): 31–42.

[9] Kuhn KA, Knoll A, Mewes HW, Schwaiger M, Bode A, Broy M, et al. (2008) "Informatics and medicine – from molecules to populations". Methods Inf Med; 47 (4): 283–295.

[10] Altman RB, Balling R, Brinkley JF, Coiera E, Consorti F, Dhansay MA, Geissbuhler A, Hersh W, Kwankam SY, Lorenzi NM, Martin-Sanchez F, Mihalas GI, Shahar Y, Takabayashi K, Wiederhold G. (2008) Commentaries on "Informatics and medicine: from molecules to populations". Methods Inf Med.;47(4):296-317.

[11] Martin-Sanchez, F et al. (2009) "Propuesta de definición de la asignatura: Informática Biomédica para los nuevos planes de estudio en Facultades de Medicina". Accesible in:

[12] http://combiomed.isciii.es/Paginas/pdfDocumentos /PropuestaAsignaturaIBMI.pdf. Fecha consulta: Junio 2010.

[13] Hersh W, Williamson J. (2007) "Educating 10,000 informaticians by 2010: the AMIA 10 × 10 program". Int J Med Inform; 76 (5–6): 377–382.

[14] Feldman SS, Hersh W. (2008) "Evaluating the AMIA-OHSU 10×10 program to train healthcare professionals in medical informatics". AMIA Annu Symp Proc 2008. pp 182–186.

[15] Gonzalez Bernaldo de Quiros F, Luna D, Otero P, Baum A, Borbolla D. (2009) "Spreading knowledge in medical informatics: the contribution of the Hospital Italiano de Buenos Aires". Yearb Med Inform. pp 147–152.

[16] COACH (YYYY). Health Informatics Professionalism (HIP™). http://coachorg.com/career_development

[17] Detmer DE, Munger BS, Lehman CU. (2010). "Clinical Informatics Board Certification: History, Current status, and Predicted Impact on the Clinical Informatics Workforce". Applied Clinical Informatics 1:11-18.

[18] HISA 2011 Health Informatics Society of Australia Tertiary Course Directory. http://www.hisa.org.au/tertiary

[19] Tse, J., & O’Shea, C. (2008). Getting runs on the scoreboard - development of a formal health informatics curriculum statement for the RACGP. In H. Grain, (Ed). HIC 2008 Conference: Australia’s Health Informatics Conference; The Person in the Centre, August 31 - September 2, 2008 Melbourne Convention Centre. Brunswick East, Vic.: Health Informatics Society of Australia, [210]-[213].

[20] Foster, J., & and Bryce, J. (2009). Australian nursing informatics competency project. In: Proceedings of the 10th International Congress on Nursing Informatics: Connecting Health and Humans, 28 June - 1 July 2009, Helsinki. Retrieved July 4, 2011, from http://eprints.qut.edu.au/31927/1/c31927a.pdf

[21] AHIEC 2010 Australian Health Informatics Education Council. http://www.ahiec.org.au/

[22] Hansen, D., Gurney, P., Morgan, G., & Barraclough, B. (2011). The Australian e-Health Research Centre: Enabling the health care information and communication technology revolution. Medical Journal of Australia, 194(4), S5-S7.

[23] Mendis, K. (2007). Health informatics research in Australia: retrospective analysis using PubMed. Informatics in Primary Care, 15(1):17-23.

[24] [HISA] Health Informatics Society of Australia / Michael Legg & Associates. (2009). Review of the Australian Health Informatics Workforce. Brunswick, VIC: HISA. www.hisa.org.au/system/files/u2233/_Informatics _Workforce_Review_v1_1_-_SUMMARY.pdf

[25] NHMRC (2010). National Health and Medical Research Council Health Informatics Data Set. http://www.nhmrc.gov.au /grants/research-funding-statistics-and-data/funding-datasets/health-informatics

[26] NEHTA 2011 National e-Health Transition Authority Strategic Plan Refresh 2011-2012. http://www.nehta.gov.au /component/docman/doc_download/1338-nehta-strategic-plan-20112012

[27] Smith, S., Drake, L., Harris, J., Watson, K., & Pohlner, P. (2011). Clinical informatics: A workforce priority for 21st century healthcare. Australian Health Review, 35, 130-135.

[28] ACHI 2011 Australasian College of Health Informatics Membership Benefits, Applications and Renewals. http://www.achi.org.au/Membership.htm

[29] Lopez-Campos G, Lopez-Alonso V, Martin-Sanchez F. (2010). "Training health professionals in bioinformatics. Experiences and lessons learned". Methods Inf Med.;49(3):299-304.

[30] Demiris G. (2007) "Interdisciplinary innovations in biomedical and health informatics graduate education". Methods Inf Med; 46 (1): 63–66.

[31] van Mulligen EM, Cases M, Hettne K, Molero E, Weeber M, Robertson KA, et al. (2008) “Training multi-disciplinary biomedical informatics students: three years of experience”. J Am Med Inform Assoc; 15 (2): 246–254.

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

Jana Zvárová[1,2,3], **Štěpán Svačina**[1,3], **Taťjana Dostálová**[1,3], **Michaela Seydlová**[1,3], **Karel Zvára**[1,2], **Vendula Papíková**[1,2], **Miroslav Zvolský**[1,2], **Čestmír Štuka**[3], **Martin Vejražka**[3], **Jitka Feberová**[3]

[1]Center of Biomedical Informatics, Prague, Czech Republic

[2]Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic

[3]Charles University in Prague, Czech Republic

Abstract

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

Keywords

education, biomedicine, informatics, e-learning, healthcare

Correspondence to:

Jana Zvárová
Centre of Biomedical Informatics,
Institute of Computer Science AS CR
Address: Pod Vodárenskou věží 2, 182 07 Prague 8, Czech Republic
E–mail: zvarova@euromise.cz

EJBI 2011; 7(2):72–78
received: August 3, 2011
accepted: October 12, 2011
published: December 23, 2011

1 Introduction

Educational programmes in the area that we nowadays refer to as biomedical informatics cover topics from the field of medical informatics and bioinformatics. The conceptual roots of such programmes lead back more than thirty years and the programmes are well established in many countries. The leading role in promoting activities concerning education in biomedical informatics has been given by the International Medical Informatics Association (IMIA) at MEDINFO congresses, special topics conferences and activities of the IMIA working group on Health and Medical Informatics Education. This working group initiated the development of the first IMIA Recommendations on Education in Health and Medical Informatics [1] translated till now into Spanish, Chinese, Italian, Turkish, Czech, and Japanese languages. These recommendations were updated and the second version was published in [2]. Let us mention at least the IMIA conference on medical informatics education held in Prague 1990. It brought together participants from 18 countries and the „Knowledge, Information and Medical Education" proceedings [3] contained more than 60 selected contributions and covered the role of informatics in the medical curriculum and experiences existing in many medical faculties all over the world. This conference highly influenced medical informatics education at medical faculties of Charles University in Prague. After the political changes in Czechoslovakia in the year 1989, education and training in medical informatics at Charles University in Prague have been further developed. The involvement of teachers in several European projects and broader availability of knowledge acquired from national and international contacts with universities, research organizations and working groups of international organizations, e.g. the International Medical Informatics Association (IMIA) and the European Federation for Medical Informatics (EFMI), supported new approaches to medical informatics education. During the 58th World Health Assembly held in Geneva in May 2005, the Ministers of Health of 192 member states of the United Nations approved the so called eHealth Resolution [4] that officially recognizes the added value of the information and communication technologies for health purposes. eHealth technologies opened the doorway to a new type of medical services where healthcare professionals are able to utilize them fully for prevention and management of diseases, lifelong learning and communication with colleagues and patients. Additionally, education and use of eHealth technologies can help to change a passive attitude of patients against their diseases towards a proactive attitude of informed citizens for managing their own health. It is expected that an increasing development of eHealth applications considering not only electronic but also environmental and economic context [5] will influence also the medical informatics education and training.

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

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

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

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

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

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

3 Internet and e-learning Tools

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

3.1 Wiki Teaching Materials at the First Faculty of Medicine

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

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

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

3.2 Interactive Electronic Books, Videofilms and Audio Presentations of Lectures

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

3.3 ExaMe System

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

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

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

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

3.4 Web 2.0-based e-learning Tools

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

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

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

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

3.5 Other e-learning Tools

Further we describe three other tools used in biomedical informatics education. The system BAYES helps to explain the Bayesian approach to the design of research studies in health sciences. The central idea of the Bayesian method is the use of study data to update the state of knowledge about a quantity of interest. In study design, the Bayesian approach explicitly incorporates expressions for the loss resulting from an incorrect decision at the end of the study. The software tool demonstrates the Bayesian approach by generating numeric examples and thus helps students to understand the basic principles of the method including sensitivity and specificity of a test, prevalence of a disease, the ROC curve, etc. The system works in Czech and English languages.

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

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

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

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

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

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

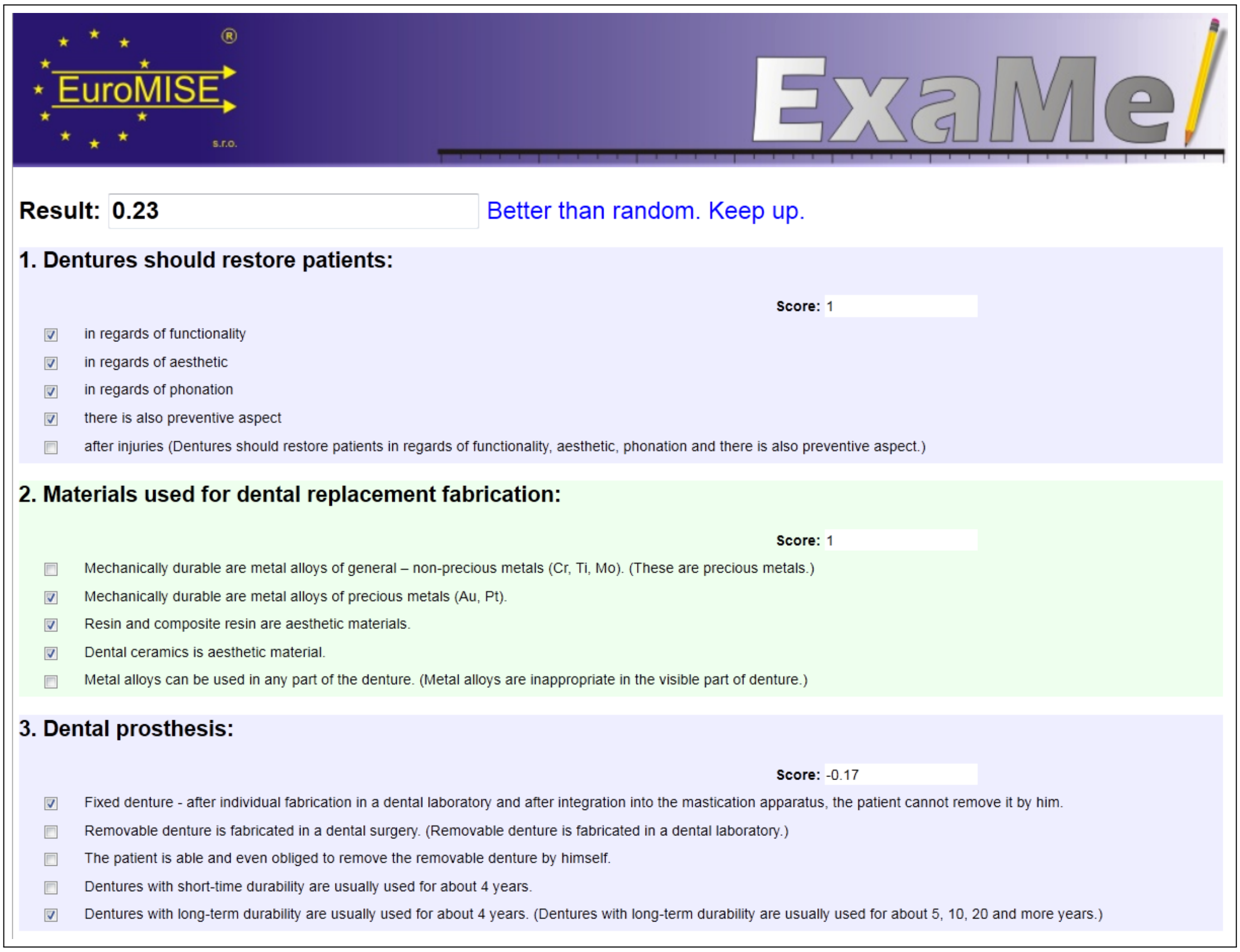

Figure 1: Screen of the ExaMe system.

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

5 Conclusions

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

Acknowledgements

The work was partially supported by the 1M06014 project of the Ministry of Education, Youth and Sports CR.

References

[1] Haux R et al.: Recommendations of the International Medical Informatics Association (IMIA) on education in health and medical informatics Methods of Information in Medicine 2000; 39: 267-77

[2] Mantas J. et al.: Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics, First Revison. Methods of Information in Medicine 2010; 49 2: 105-120

[3] Van Bemmel JH, Zvárová J. (eds.) Knowledge, Information and Medical Education, Elsevier, Amsterdam 1991

[4] Healy JC. The WHO eHealth resolution - eHealth for all by 2015? Methods Inf Medicine 2007, 46:2-5

[5] Zvarova J, Zvara K. e3Health: Three Main Features of Modern Healthcare. In: Moumtzoglou A, Kastania A. E-Health Systems Quality and Reliability: Models and Standards, 2010; 18–27.

[6] Zvarova J, Engelbrecht R, van Bemmel JH. Education in Medical Infor-matics, Statistics and Epidemiology, Int J Med Inform 45, 1/2, 1997, 3 – 8

[7] IT EDUCTRA CD. Commision of the European Communities, 1998

[8] Van Bemmel JH, Musen MA. Handbook of Medical Informatics. Heidelberg-New York: Springer Verlag, 1997

[9] Shortliffe EH, Cimino J. Biomedical Informatics. Springer Verlag, New York 2006

[10] Hasman A, Albert A, Wainwright P, Klar R and Sosa M, eds.: Education and Training in Health Informatics in Europe, IOS Press, Amsterdam 1995

[11] Hovenga EJS, Mantas J. (eds). Globalization of Health Informatics Education. Studies in Health Technology and Informatics, Vol 109, IOS Press 2004

[12] Zvarova J, Svacina S: New Czech Postgraduate Doctoral Program in Biomedical Informatics In: G. Surjan, R. Engelbrecht, P. McNair (eds). Health Data in the Information Society, Proceedings of MIE2002, Amsterdam, IOS Press; 2002, 766-769

[13] Dostalova T, Seydlova M, Zvarova J, Hanzlicek P, Nagy M. Computer-Supported Treatment of Patients with the TMJ Parafunctions. In: Blobel B, Pharow P, Zvarova J, Lopez D (eds) eHealth: Combining Health Telematics, Telemedicine, Biomedical Engineering and Bioinformatics to the Edge. Berlin, IOS Press 2008; 171-177

[14] Zvarova J, Zvara K. Evaluation of knowledge using Exa-Me program on the internet. In: Iakovidis I, Maglaveras N, Trakatellis A (eds). User acceptance of health telematics applications, Amsterdam, IOS Press 2000; 145-151

[15] Peleska J, Anger Z, Buchtela D, Sebesta K, Tomeckova M, Vesely A, Zvara K, Zvarova J: Formalization of Medical Guidelines, European Journal for Biomedical Informatics 2005

[16] Dostalova T., Seydlova M. et al. Dentistry and Oral Diseases. Grada, Prague 2010

[17] Elkin P.L.et al: Secondary Use of Clinical Data. In: Blobel et al. (Eds) Seamless Care-Safe Care. IOS Press 2010; 14-29.

