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*