Health Informatics

Eta S. Berner *Editor*

Informatics Education in Healthcare

Lessons Learned

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ISBN 978-1-4471-4077-1 ISBN 978-1-4471-4078-8 (eBook)
DOI 10.1007/978-1-4471-4078-8
Springer London Heidelberg New York Dordrecht

Library of Congress Control Number: 2013948756

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

To our students, from whom we have learned much.

Preface

Twenty years ago almost the only individuals involved in healthcare who had even heard the term "informatics" were those who identified themselves as medical or nursing informaticians. Today, we have a variety of subfields of informatics including not just medical and nursing informatics, but informatics applied to other health professions (such as dental or pharmacy informatics), as well as health informatics, biomedical informatics, bioinformatics and public health informatics among others.

This book addresses the broad range of informatics education programs available today. My own background in health professions education over 40 years ago at the beginning of my career and in online informatics education in my work today has provided me with a tacit understanding of the breadth of content, pedagogical techniques, strategies and approaches to informatics education in a wide variety of areas. As a leader of UAB's Center for Health Informatics for Patient Quality and Safety and the UAB Curriculum Development Center that was part of ONC's health IT workforce development program, I have seen the rapidly growing interest in the development of new informatics education programs.

The aim of this book is to make the tacit knowledge explicit and to share some of the lessons learned by a group of very experienced informatics educators. The contributors to this volume are internationally recognized informatics educators and this short preface cannot do justice to their expertise. However, to give the reader a snapshot of their knowledge and experience, the following is a description of the contributors' expertise as related to the particular chapters that they wrote.

Dr. Jacqueline Moss, who co-authored the overview chapter with me, is an experienced nursing informatics educator, who has been integrally involved in informatics education at the national level and throughout her institution in other areas in addition to nursing informatics. The authors of Chap. 2 have taken the insights gained by years of experience in online education and articulated them in a series of strategies that will be useful for others, especially those who have struggled with the issues that are raised. In addition to my own expertise in online informatics education, the other authors bring additional expertise and experience. *Ms. Lorrinda Khan* has years of online learning experience, both as an instructor and as an instructional design expert. *Dr. Michael Dieter* is currently program director for the online masters of health informatics program at the University of Illinois at Chicago (UIC), where *Dr. Annette Valenta* had also served as program director. In addition, Dr. Valenta is the developer of the AMIA 10×10 program at UIC.

The authors of the chapters describing different training programs in the US have direct experience with the programs they describe. *Dr. Valerie Florance* is Associate Director of Extramural Programs at the National Library of Medicine (NLM) and has been responsible for oversight of the many NLM-funded informatics training programs. *Drs. Reed Gardner* and *Charles Safran* were leaders of the task forces that led to the approval of the clinical informatics subspecialty. They also both are members of the certification examination test committee. In addition to Dr. Moss, *Dr. Beth Elias* is co-author of the chapter on nursing informatics. Dr. Elias teaches in a variety of nursing informatics areas, including nationally funded nursing education projects. *Amanda Dorsey* and *Meg Bruck* bring the perspective of both health informatics students and instructors to their chapter. They were both students in the University of Alabama at Birmingham (UAB) MSHI program and have gone on to become broad-based informatics educators. Ms. Dorsey led the transition of the MSHI program to an online format and Ms. Bruck also teaches a variety of courses in health informatics as part of the ONC workforce development program. Both Ms. Dorsey and Ms. Bruck also participated in the ONC Curriculum Development Centers program. The final two chapters in this section are written by *Dr. William Hersh*. Dr. Hersh is internationally recognized as an informatics educator. He is the leader of OHSU's informatics education activities which include not only the NLM-funded informatics training program, but also the University-based training program funded by ONC as part of the ONC workforce development program. He has been a leader in other ONC-funded workforce programs including the Curriculum Development Centers program and the National Training and Dissemination Center. In addition to his work with the ONC workforce programs, Dr. Hersh was the impetus behind the AMIA 10×10 program and was director of the first 10×10 program.

The contributors of the chapters on informatics education programs for other health professionals bring a similar breadth of experience as those for the dedicated informatics programs. *Dominic Covvey* is internationally recognized for leading the development of competency descriptions for multiple roles including informatics researchers, applied informaticians, and clinician users of informatics applications. *Margaret Schulte* was the leader of the HIMSTA project described in Chap. 10 and also has years of experience as both a leader of HIMSS' education activities and in her work with the Commission on Accreditation of Health Management Education (CAHME). *Dr. Chiquito Crasto* has expertise in bioinformatics and has been working for several years developing the innovative bioinformatics education program he describes in Chap. 11. *Drs. Peter Embi and Philip Payne* are widely recognized as the major leaders in the US in the area of clinical research informatics (CRI). Dr. Embi led the first AMIA CRI conference and also developed the AMIA 10×10 course in this area. Both authors have published seminal articles in this domain.

All of the chapter authors on worldwide informatics education are experienced educators within their own country and around the world. *Dr. John Holmes* and *Jeffrey Williamson* were instrumental in working with AMIA's Global Health Informatics Partnership which was involved with disseminating informatics educational materials to countries around the world. The authors of Chap. 14, *Drs. Paula Otero* (Latin America), *Antoine Geissbuhler and Caroline Perrin* (Sub-Saharan Africa), and *Ngai-Tseung Cheung*, *Nawanan Theera-Ampornpunt*, *and Kwok Chan Lun* (Asia Pacific) have developed highly regarded informatics education programs in the respective regions that they discuss.

In addition to the outstanding contributions of the chapter authors, and the support of Grant Weston and the Springer editorial team, I would like to thank Ms. Joy Ptacek whose assistance with this book and with all of our informatics educational activities, has provided the support that was essential in bringing this book to fruition. I think I speak for many of the contributors to this volume in also expressing our appreciation to the US Office of the National Coordinator for Health Information Technology (ONC), and to Charles Friedman, Ph.D., in particular, whose vision in developing and funding the ONC health IT workforce development program has provided the stimulus for the enhancement of informatics education programs around the world.

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Acronyms and Abbreviations

AACN	American Association of Colleges of Nursing
AAMSI	American Association for Medical Systems and Informatics
ABMS	American Board of Medical Specialties
ABP	American Board of Pathology
ABPM	American Board of Preventive Medicine
ACGME	Accreditation Council for Graduate Medical Education
ACMI	American College of Medical Informatics
AHI	Applied Health Informatics
AHIMA	American Health Information Management Association
AMIA	American Medical Informatics Association
ANA	American Nurses Association
ANCC	American Nurses Credentialing Center
APAMI	Asia Pacific Association for Medical Informatics
ARRA	American Recovery and Reinvestment Act
ASL	Asynchronous Learning
AUPHA	Association of University Programs in Health Administration
BIOTEC	National Center for Genetic Engineering & Biotechnology [Thailand]
BISTI	Biomedical Information Science and Technology Initiative
BSN	Bachelor of Science in Nursing
CAHIIM	Commission on Accreditation for Health Informatics and Information Management
CAHIMS	Certified Associate in Health Information & Management Systems
CAHME	Commission on Accreditation of Healthcare Management Education
CBMI	Regenstrief Institute Center for Biomedical Informatics
CCNE	Commission on Collegiate Nursing Education
CDC	Curriculum Development Center
CE	Continuing Education
CEO	Chief Executive Officer

CERTES	Center for Research Expertise in Telemedicine and eHealth [Centre d'Expertise et de Recherche en Télémédecine et E-santé]
CHCF	California Healthcare Foundation
CHI	Center for Health Informatics [Singapore]
CHIRAD	Centre for Health Informatics Research and Development [South Africa]
CIN	Computers, Informatics, Nursing [Journal]
CIO	Chief Information Officer
CMIO	Chief Medical Information Officer
CMS	Centers for Medicare and Medicaid Services
CMS	Clinical Management System [Hong Kong]
COSTAR	Computer Stored Ambulatory Record
CPHIMS	Certified Professional In Health Information & Management Systems
CPOE	Computerized Physician (or Provider) Order Entry
CRI	Clinical Research Informatics
CTRI	Clinical and Translational Research Informatics
CTSA	Clinical and Translational Science Awards
DHHS	Department of Health and Human Services [US]
DNP	Doctor of Nursing Practice
EBM	Evidence-based Medicine
EBP	Evidence-based Practice
EDUCTRA	Education and Training in Health Informatics
EFMI	European Federation for Medical Informatics
EHR	Electronic Health Record
EMR	Electronic Medical Record
EMRAM	Electronic Medical Record Adoption Model (HIMSS)
ENRICH	Enhancing Research & Informatics Capacity for Health Information in Colombia
EU	European Union
EXPASY	Expert Protein Analysis System
FEMI	Federación Médica del Interior [Uruguay]
FOA	Funding Opportunity Announcement
G2HI	Gateway to Health Informatics [Singapore]
GBS	Graduate Biomedical Sciences
GHIP	Global Health Informatics Partnership
GMDS	German Medical Informatics Association
GNU	Refers to a free software license
GPRS	General Packet Radio Service
GWAS	Genome-wide Association Studies
HELINA	Health Informatics in Africa
HELP	Health Evaluation Through Logical Processing
HIBA	Hospital Italiano of Buenos Aires
HIBBS	Health Informatics Building Blocks
HIM	Health Information Management

HIMSS	Healthcare Information & Management Systems Society
HIMSTA	Health Information Management Systems Technology and Analysis
HIPAA	Health Insurance Portability & Accountability Act
HIT	Health Information Technology
HITECH	Health Information Technology for Economic & Clinical Health
HITPRO™	Health Information Technology Competency Exams
HSP	Hybrid Skills Development Program [Singapore]
ICT	Information and Communication Technologies
IDA	Infocommunications Development Authority [Singapore]
IMIA	International Medical Informatics Association
INFOMED	Telematic Network for Health [Cuba]
INS	Informatics Nursing Specialist
IOM	Institute of Medicine
IR	Information Retrieval
IS	Information Systems
ISD	Information Services Department
ISfTeH	International Society for Telemedicine and e-Health
IT	Information Technology
ITU	International Telecommunications Union
JAMA	Journal of the American Medical Association
JAMIA	Journal of the American Medical Informatics Association
KHI	Kigali Health Institute
LDS	Latter Day Saints
LMS	Learning Management System
MIT	Massachusetts Institute of Technology
MLAA	Medical Library Assistance Act
MOC	Maintenance of Certification
MOOC	Massive Open Online Course
MRI	Magnetic Resonance Imaging
MRS	Medical Record System [OpenMRS]
MSHIM	Master of Science in Health Information Management
MSN	Master of Science in Nursing
MU	Meaningful Use
MUMPS	Massachusetts General Hospital Utility Multi-Programming System
NCBI	National Center for Biotechnology Information
NCHS	National Center for Health Statistics
NCSBN	National Council for State Boards of Nursing
NEHR	National Electronic Health Record [Singapore]
NHIP	National Healthcare Information Project [Taiwan]
NIH	National Institutes of Health
NIHI	National Institutes of Health Informatics (Canada)
NLM	National Library of Medicine
NRSA	National Research Service Award
NTDC	National Training and Dissemination Center
NUR	National University of Rwanda

NUS	National University of Singapore
OER	Open Education Resources [OER Africa]
OHSU	Oregon Health & Science University
ONC	Office of the National Coordinator [for Health Information Technology]
PAHO	Pan American Health Organization
PDB	Protein Data Bank
PHR	Personal Health Record
proTICS	Professionalization Program in Information Technology & Communication in Health
PURE-HIT	Professional University Resources and Education for Health Information Technology
QUIPU	Andean Global Health Informatics Research & Training Center
RAFT	Reseau en Afrique Francophone pour la Télémédecine [Research in Africa for Telemedicine]
RCR	Responsible Conduct of Research
RDHI	Research and Development Health Informatics
REACH-Informatics	Regional East African Center for Health Informatics
REC	Regional Extension Center
REHCE	Regional e-Health Center of Excellence [Kigali]
REIMICOM	Malian Medical Information and Communication Network
RHIT	Registered Health Information Technician
RN-BC	Registered Nurse – Board Certified
SCAMC	Symposium on Computer Applications in Medical Care
SWOT	Strengths Weaknesses Opportunities Threats [Analysis]
TBI	Translational Bioinformatics
TIGER	Technology Informatics Guiding Education Reform
TMI	Thai Medical Informatics Association
TMT	Taiwan Electronic Medical Record Template
UAB	University of Alabama at Birmingham
UBT	University-based Training
UCSF	University of California-San Francisco
UIC	University of Illinois at Chicago
UP-HI	University Partnership for Health Informatics [University of Minnesota]
VistA	Veterans Health Information Systems and Technology Architecture
WEB	Workshop on Education in Bioinformatics
WHO	World Health Organization

Part I
Introduction to Lessons Learned

Chapter 1
Introduction and Overview

Eta S. Berner and Jacqueline A. Moss

Abstract With the increase in the use of health information technology in clinical and research settings there has been an increasing interest in the development of health and biomedical informatics education programs. This chapter describes the content of the book and the themes contained within it. In addition to the introductory and concluding sections, the book is divided into three sections: (1) Training Informatics Specialists in the U.S.; (2) Informatics Education for Other Health Professionals; and (3) Informatics Education Worldwide. Common themes across chapters include the multidisciplinary basis of informatics education, the identification of informatics competencies and criteria for certification of individuals and program accreditation, and the need to adapt to current and future healthcare delivery and informatics needs. In addition, strategies for online informatics education are discussed in many chapters. The book concludes with a synthesis of lessons learned.

In the last 20 years, there has been a proliferation in the number and types of informatics education programs. The interest in health and biomedical informatics education has increased dramatically in response to the increase in use of healthcare information technology (HIT) in both clinical and research settings. Accompanying the growth in these programs is the concurrent interest in the development

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_1, © Springer-Verlag London 2014

of informatics certification processes and program accreditation standards. Some of the impetus for informatics education in the U.S. comes from the growing use of HIT in clinical settings as a result of the HITECH Act [1], a part of the American Recovery and Reinvestment Act, which tied adoption of Health IT to incentives from the Centers for Medicare and Medicaid Services (CMS). In research settings, drivers for the increased use of health IT include the growing interest in personalized medicine, the growth of the bioinformatics field, and the emphasis on biomedical informatics to support research as a part of the Clinical and Translational Science Awards (CTSA). In other countries, as in the U.S., as the technological infrastructure has grown there is also increasing use of HIT and the concomitant need for education not only for informatics professionals, but for the clinicians and others who will use the systems.

While there have been many definitions of informatics in the literature over the years [2–6], as well as in this book, it is more productive to examine the scope of the field, rather than a specific definition, when we talk about education in informatics in healthcare. The following description of the scope of the field was developed by the first author (ESB), with some recent adaptation, 15 years ago as a result of conversations with her students, each of whom thought the educational program they were entering was covering a different aspect of the field.

> Informatics involves developing and utilizing a broad range of **information technology** to facilitate the collection, management, exchange, analysis, use (and re-use) and storage of **patient** (**including clinical and genomic**), **fiscal**, **and administrative information** to support and improve (1) the **quality** of patient care and health outcomes, (2) **secure access** to information, (3) professional and organizational **efficiency**, and (4) the **decision making** capabilities of health professionals, administrators and others within the healthcare organization.

The highlighted areas above indicate that information technology supports the field, but the focus of informatics is on the **information**, rather than the technology per se. This book describes the major initiatives in informatics education, not only in the U.S., but worldwide. It includes education to produce informatics researchers, applied informatics practitioners, and informatics education programs for other healthcare practitioners as well. The focus is on the lessons learned from the variety of health and biomedical informatics programs, some of which are fairly young, while others have been established for decades. Although we will describe a variety of types of programs for different audiences, some common themes run through them.

Interdisciplinary Basis

The practice of informatics and therefore the education necessary for this practice draws on knowledge from a wide variety of disciplines. Informatics practice, and the research of phenomena central to this practice, involves knowledge that informs the optimal design of information systems for the optimization of data collection, delivery, and analysis, as well as usefulness and usability for end-users. All of the relevant knowledge and skills related to aspects of organizational science, information science, human factors, computer science, and cognitive science must also be nested within the associated healthcare context. This context may be primarily driven by who will be the end users, such as in consumer informatics, nursing informatics or pharmacy informatics, or it may be driven by the setting, such as in public health informatics.

All informatics education programs, regardless of their healthcare focus, include content from these other related disciplines and apply this content to either the design of research for the generation of knowledge in informatics or the application of this knowledge to the practice environment. Each group applies this interdisciplinary content in relation to their healthcare focus, however all informatics specialties are based on the same or very similar theoretical underpinnings. Several of the chapters in this book explicitly describe curricular content in some detail and the interdisciplinary nature of the content is obvious.

Informatics Competencies

Another consistent theme echoed by multiple contributors to this edition, is the assertion that all healthcare professionals require basic competencies in the use of information technology to work in today's technology rich environment. A competency is 'an expected level of performance that integrates knowledge, skills, abilities, and judgment' [7] (page 12). First, all healthcare professionals need to acquire basic computer competencies to be able to interact, not only with electronic medical records, but also with a variety of patient and information and communication technologies that are increasingly a part of every aspect of healthcare. Second, every healthcare professional needs to be information literate. Finding, evaluating, and synthesizing the best evidence helps ensure that patients receive the highest level of care available from their providers. Those managing the organization and delivery of this care require current and accurate information on how to effectively and efficiently manage care access and organizational resources. Finally, all healthcare professionals require basic competencies related to the management and analysis of data. Development of data management competencies enables individuals and organizations to understand the need for ensuring the privacy and confidentiality of data, standardized data collection, and patient and organizational outcomes analysis. Chapters 4, 9, and 10 in particular list competencies that reflect these emphases and provide references that include the recommended competencies in more detail.

Standards for Certification and Accreditation

As the field of informatics education has matured there has been an increasing interest in certification of individuals' competencies and accreditation of informatics education and training programs that produced these individuals. Different organizations are often involved in certification of individuals than are involved in the accreditation of the programs preparing these students. The International Medical Informatics Association has focused on informatics education program accreditation on a worldwide basis [8]. In this book we include other examples of accreditation efforts. For instance, as described in Chap. 10, the Commission on Accreditation of Healthcare Management Education (CAHME) is responsible for accrediting programs in healthcare management. Within their accreditation guidelines are the information management competencies that are expected to be taught. None of these accreditation programs oversees a certification program for individuals. On the other hand, there are certification programs for individuals that are not specifically tied to program accreditation. The HITPRO examination that was initially designed for students graduating from the ONC-funded workforce program (see Chap. 7) does not require specific educational preparation for the credential. The CPHIMS credential, administered by the Health Information and Management Systems Society (HIMSS), that is designed to certify healthcare IT managers like those described in Chap. 6, also does not prescribe specific educational preparation. The American Nurses Credentialing Center (ANCC) in association with the American Nurses Association offers a credential for nurse informatics specialists (Chap. 5), but a different organization, the American Association of Colleges of Nursing (AACN), is involved in accrediting nursing education programs. Graduating from an accredited program is not required for eligibility for the certification examination. On the other hand, the new clinical informatics subspecialty examination for physicians described in Chap. 4 is closely tied to preparation in an accredited training program, especially after the first five years of the examination. Although the program accreditation will be done by the Accreditation Council for Graduate Medical Education (ACGME), there is close collaboration in this case between the organizations that certify individuals and accredit programs.

Currently, very few of the informatics training programs that are described in this book have undergone formal accreditation, although the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM) [9], which began as a Health Information Management (HIM) accrediting body, has now added health informatics to its name and some informatics programs are starting to seek accreditation from them. As informatics education programs proliferate and more individuals are trained, we can expect to see that both individual certification and informatics education accreditation will become more important.

Adaptation to Current and Future Needs

One of the challenges of developing informatics education programs in today's world is that the world keeps changing and the change is in the direction of requiring more and varied informatics competencies, even if one is not an "informatician" and especially if one is. 'Big data' and 'data science' have become buzzwords [10], but being able to use the data that, with the help of electronic health records we are now able to collect, will require some traditional and some new informatics competencies. Similarly, the focus on Meaningful Use in the U.S. [11] is leading to more interest in informatics-trained professionals (see Chaps. 4 and 7). New developments in genomic research have spurred the development of programs in bioinformatics education (Chap. 11), as well as programs for translational scientists [12] that integrate both clinical and bioinformatics (Chap. 12). Existing programs for health professionals have also seen the need to incorporate informatics into the basic educational preparation of clinicians (Chaps. 5 and 9) and other health professionals (Chap. 10). Chapter 6 focuses directly on the need to adapt curricula to a changing external environment, but virtually all of the chapters recognize that informatics competencies will change and evolve as the environment in which they apply changes.

Online Education

One of the major changes that has been occurring in education generally, and informatics is no exception, is a trend toward more and more education being delivered online via distance learning technology. Several programs described in this book are either primarily or entirely delivered online (see Chaps. 5, 6, 7, 8, 11, 12, 13, and 14). Examples of online curriculum content, strategies for creating online content, and feasible methods of content delivery are included in these chapters. Chapter 2 is focused exclusively on online education, specifically on the different assumptions and expectations of students and teachers in online education as compared to face-to-face programs. While the focus of this book is on informatics education, and not distance learning per se, there is a great deal of information for those who want to start a distance-accessible informatics education program.

Arrangement and Focus of Book

This book is arranged in three major sections with an introductory and concluding section. This overview and the chapter on online education (Chap. 2) form the introductory section. The three major sections include chapters on:

1. Training Informatics Specialists in the U.S.
2. Informatics Education for Other Health Professionals
3. Informatics Education Worldwide

The section on training informatics specialists in the U.S. includes chapters on the National Library of Medicine (NLM) training programs (Chap. 3), the curricula and certification procedures for the clinical informatics medical subspecialty (Chap. 4), programs to train IT managers and other IT and informatics workforce professionals (Chaps. 6 and 7), and continuing education in informatics, specifically the AMIA 10 × 10 programs which have been used not just in the U.S., but in other countries as well (Chap. 8). Chapter 5 on Nursing Informatics focuses on both training nurse informaticians as well as integrating informatics into general nursing curricula.

The other chapters that involve integrating informatics education into other educational programs are covered in the next section, Informatics Education for Other Health Professionals. These professionals include physicians (Chap. 9), health administrators (Chap. 10), clinical and translational researchers (Chap. 12). Chapter 11 focuses on integrating bioinformatics teaching into the training of basic science researchers.

The third major section of this book includes chapters on informatics education around the world. Chapter 13 includes a description of the efforts and challenges of translating some of the U.S. programs into educational programs in other countries. Conversely, Chap. 14 provides the perspectives of the recipients of some of those programs, as well as a description of informatics education programs developed in the local settings. The focus of Chap. 14 is on the many countries with limited resources for healthcare in general, and for informatics education in particular.

Each chapter of the book ends with lessons learned and/or key take-away points. The last, Chap. 15, synthesizes and integrates these points for a comprehensive view of the lessons learned from the variety of informatics education programs described.

While the lessons learned provide 'words of wisdom' from internationally recognized informaticians and educators, the references in this book provide a comprehensive compilation of the scholarly literature on the history and current status of informatics education in the U.S. and globally. Both the lessons and the references will be useful for informatics educators who are embarking on developing the new informatics education programs that are sorely needed as we enter the digital healthcare age.

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Chapter 2
Managing Unspoken Assumptions in Online Education

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Abstract Informatics educational programs are increasingly being offered in a distance learning mode and are often taught by informatics educators who have taught in traditional settings, but are less experienced with online education. There are resources for developing online curricula, but these resources rarely address the tacit and unspoken assumptions that students and teachers bring to online educational programs. This chapter is designed to help the online educator become more aware of these unspoken assumptions and to develop strategies for making assumptions explicit, managing student expectations and preventing common problems that occur in distance learning programs. The concept of transactional distance is discussed as a theoretical framework for understanding and managing student and faculty expectations around the flexible class hours in asynchronous learning environments, the challenges of transferring teaching strategies from the face-to-face classroom, and the issues raised specifically by students and faculty expectations of the technology.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_2, © Springer-Verlag London 2014

The explosion nationally in popularity of online education carries with it significant implications – both obvious and not so obvious – for students and instructors alike. New technologies, continually emerging, carry with them the promise of new and improved experiences for the individual users, but often carry with them new challenges. In this chapter, a frequently overlooked challenge in asynchronous online education will be explored. In asynchronous education, lessons (e.g., lectures, reading materials, discussion questions, other assignments) are posted online and students respond to the lessons on their own schedule, usually over a defined time period for each lesson. This differs from synchronous online education in which both instructors and students are online together at the same time. In asynchronous online education, the most frequent means of communication surrounding that instructional content among students and instructor(s) is via a discussion board or email.

While significant literature exists on new technologies and online pedagogical techniques, which includes some publishing houses having a division whose sole focus is online education, there has been little written on how instructor and student assumptions and expectations can derail what, in theory, should be an exciting technologically enhanced learning environment. This chapter will identify some of those assumptions, describe their impact, and suggest ways that they can be addressed. The ideas and strategies were developed based on the authors' experience over 15 years in online informatics education, and apply to a variety of online educational activities.

Historically, asynchronous learning (ASL) environments share a number of common attributes with their antecedents, traditional face-to-face classrooms. Both are loci where learning potential is impacted by a range of issues originating from unspoken assumptions at a number of levels that includes institutional (universities, colleges, departments, and programs), curricular, and coursework. In ASL environments, where distance in time and space alone may create barriers to communication between instructors and students, the issue of unspoken assumptions in courses has immediate relevance to fulfilling learning potential. Instructors and students bring assumptions into learning environments, both face-to-face and online, that create expectations for performance as teachers and learners. These expectations are formed from years of experience in face-to-face education and from more recent, but potent, experience related to daily use of technology, particularly exacerbated by the upsurge in mobile technologies that changes the information delivery paradigm for today's students.

These spoken and unspoken assumptions are transformed into explicit and implicit expectations that frame perceptions of value. Unspoken assumptions create potential ambiguities of meaning and intention. For courses to be meaningful learning experiences, instructors' and students' expectations must be aligned, i.e., there must be mutual understanding and agreement between both parties for learning to proceed optimally. In order for potential ambiguities in meanings and intentions to be resolved into expectations, it is necessary for unspoken assumptions to be articulated explicitly. Assumptions swirl among the lack of defined class hours in asynchronous instruction, the differences in how students and instructors spend their time in online and face-to-face classroom settings, the assumptions that strategies effective in face-to-face instruction will work in an online environment, and the expectations fostered by features of the technology itself. In a face-to-face classroom, these unspoken, often unconscious assumptions and expectations are resolved through informal communications, which are not possible in the asynchronous online mode.

Issues Related to Flexible Class Hours

Instructors Anticipate Students Understand That Faculty Have Other Responsibilities in Addition to Teaching

Many students, even in face-to-face settings, do not realize that faculty members' academic and personal responsibilities are broader than their interaction with the students in one particular class. There are cues for students in a face-to-face setting that are impossible for students to recognize in an online environment. In fact, often there are cues in the online setting that convey just the opposite message, i.e., that faculty are available immediately on a 24/7 basis – 24 hours a day, 7 days a week.

In a face-to-face setting, students usually know they are to make an appointment to see the faculty member and that, in many settings, faculty are often either not in their office or are clearly engaged in doing other things, e.g., research or service responsibilities. Of course, students can, and do, drop by to talk to faculty, but are unlikely to do so if the faculty member is obviously preoccupied. Office hours tell students that the instructor is available to the students outside of class during defined times only, and students usually do not expect to find instructors in their classroom after normal business hours. Students in a brick-and-mortar setting can often find out easily if the faculty member is out of town. Also, the opportunity for informal conversation with faculty, before or after class, will often support communication of this information.

In the online setting, however, students communicate primarily by email, which can set up an expectation of an instant reply and an impression on the part of the student of continual instructor availability. This expectation is reinforced when faculty reply to students throughout their standard workday and, often, during evening hours. It is true that faculty also hold assumptions about student availability. Online faculty may attempt to make daytime student assignment deadlines to accommodate their own availability, or because faculty are used to teaching students whose "full-time job" is being a student. Interestingly, that typically results in a negative student response, as many online students work full-time during the day and "learn" at night.

This expectation of constant availability is not reasonable and must be negotiated overtly among faculty and online students. One way to counteract these expectations is to state clearly what the students can reasonably expect in terms of an instructor response. Clearly communicating to students when the instructor plans to travel, attend other professional events, or take time off can help to reduce confusion about when the students may expect a response. This will also convey some of the "additional responsibilities" that the instructor has. By reducing the 'unknown' element of the instructor-student electronic interaction, the instructor can effectively reduce student anxiety. Other approaches are to be clear at the start of the course that there may be delays in responding to email and to confine, intentionally, responses to students or posting in discussion groups to reasonable working hours.

Faculty Expect Online Students to Be Understanding When They Are Delayed with Grading or Other Responses to Students

In the face-to-face setting such delays often occur, and students will inquire about the status of grades or assignments, but will rarely complain. Faculty may not realize, however, that in face-to-face settings they update students informally, e.g., before starting class, they may say they are halfway through grading the papers, or that they are going out of town next the next week to a conference, etc. Similarly, students may use those informal interactions to inquire about the status of the grading if the teacher does not spontaneously say anything. This type of informal communication is unlikely to occur online, because, generally, it is not specifically planned. In the online setting, queries have to be planned as an online post or email, and students may be reluctant to take that step. While some students will freely email and ask their instructor for information, others will hesitate to express their anxiety in an email or in a public post.

In an online course, therefore, faculty must take the initiative to update students as to the status of faculty-to-student feedback. To do otherwise puts faculty at risk because technology platforms foster an expectation of instant communication, and student expectations for promptness is high. Faculty must recognize that these expectations exist and must be explicit about when students can expect responses, and if there are delays, to remember to update the students. Even if the faculty member is uncomfortable as to the cause of the delay (students should not be late, why is the faculty member?), a light-hearted apology and update is preferable to creating festering resentment or anxiety.

Issues Related to Faculty and Student Time in Online Instruction

Faculty Assume That the Amount of Time It Takes for Them to Give an Online Lecture Is the Amount of Time the Student Spends Listening to It

In the face-to-face classroom or in a synchronous online lecture, this assumption is certainly true. Experienced instructors usually can estimate how much material can be covered in a given amount of class time and prepare their lectures accordingly, recognizing that in a face-to-face (or synchronous online) setting, such presentations are often punctuated by questions, jokes, presenters diverging from topic, planned or unplanned discussion, etc.

In an asynchronous narrated online lecture, many of these distractions are not present, and a good asynchronous online presentation will usually take half to a third of the time to deliver compared to an equivalent lecture for a face-to-face class. This difference in delivery time can lead the instructor to prepare presentations that are too dense or too long. Ironically, it is the distractions in the face-to-face setting that make it tolerable for students to participate in an hour-long class period. It is much more difficult to maintain attention sitting at their home computer for that same period of time. Additionally, in a face-to-face setting, students who do not understand all of the material or who have trouble getting everything down in their notes may briefly ask the teacher for clarification after or during class. More often, they will just "make do" with incomplete understanding or will seek clarification from others after class.

In an online mode, in part because the technology allows it and also because there are less likely to be other students available for clarification, the student may listen repeatedly to the lecture. This combination (too long or too 'dense' online presentations, listened to multiple times) can make the material very burdensome for the student and lead to resentment of, and difficulty managing, the amount of time the class takes.

Faculty must realize that their delivery time for an online presentation will be considerably shorter than the time the student will spend initially listening to it, but that students also may listen to it multiple times. Faculty should adjust the presentation content accordingly. It is good practice to break up a longer lecture into shorter segments – each no longer than 20 minutes – to give the students an opportunity to more feasibly manage content viewing.

Faculty Assume That the Main Difference in an Online Discussion and One in Class Is That One Is Written and the Other Is Spoken

In the online setting, students often write much more than they would say in person. In fact, in person, a good instructor would control the discussion to avoid domination by individuals, but the instructor cannot easily stop a student who writes a great deal in an asynchronous online discussion thread. Since students are no longer limited to the scheduled course meeting as their only opportunity to participate in discussion, lengthy responses do not carry the negative connotation of allowing one student to speak at the expense of another student's opportunity to participate. Instead, in an asynchronous online class, every student has an equal opportunity to share their ideas. While some of these longer responses are merely long-winded, the online environment actually provides an opportunity for longer and more thoughtful responses, and instructors are usually impressed at the quality of their students' discussion. It is not unheard of, however, to set a word limit to discussion in order to foster critical thinking and a concise writing style.

In a face-to-face setting, students may assume that unless called upon, they need not say anything. In an online setting, instructors often expect all students to participate. In a face-to-face setting, some students may not participate or the responses may be briefer or less thoughtful. Thus, there may actually be a less rich discussion in the face-to-face than in the online mode. While lively discussion is one strength of online courses, this can also lead to a greater amount of time spent on the students' part (sometimes just to read the posts) than either the student or faculty anticipated. Especially with conscientious students, if the instructor combines dense lectures with overwhelming discussion, the students will feel inundated, resentful, or may eventually cut back on their efforts.

Online educators should recognize that the time commitment for discussions may be extensive and should structure the lecture and discussion workload appropriately, so that the grading reflects the effort and the time expectations are in keeping with the goals of the discussion assignment. Another approach is to limit intentionally the extent of discussion by putting word limits or limiting the number of responses each student can make; however, this approach may make the discussion less robust.

In addition to the time spent in discussion being more extensive in an online environment, it may become less focused, in part because students may use the discussion forum for non-relevant discussions to establish a connection to their fellow students. In the face-to-face setting, both students and faculty assume that such discussions will take place primarily outside the classroom. There is no “after class” in online learning environments and if this type of discussion spills over into the class assignments, it will make the discourse even more difficult for students to navigate. Setting rules to exclude off-topic discussions diminishes the potential for building rapport and student satisfaction. Instructors can set up an optional discussion board reserved for off-topic conversations that do not directly relate to class assignments. In the experience of the authors, not only do these optional discussion boards allow students to share life event experiences, they also have included examples of students helping each other with informatics challenges in the work environment. Also, they often have involved very substantive discussion of current issues in informatics that were not anticipated by the faculty when the formal assignments were planned.

Issues Related to Lack of Transfer of Effective Face-to-Face Strategies to the Online Environment

Instructors Assume That Students Will Let the Teacher Know if They Are Confused

It must never be assumed, in live or online settings, that all students will admit ignorance or actively confront the faculty if lecture material or assignment expectations are unclear. Most students are unlikely to do so explicitly; however, in live settings, good instructors will notice confused (or bored) looks on the students' faces or other body language and will adapt their presentations accordingly. Self-assessment exercises (such as lessons learned or journal assignments) or frequent quizzes can address this to some extent online, but these are not in the "real time" of body language feedback to the instructor. In the absence of this feedback, instructors may erroneously assume all is well.

Similarly, to cement their own learning, some students may need other students to immediately (and informally) validate their understanding. Students may not be aware of this need, or may not want to express it, but they may miss that real-time contact in asynchronous learning settings.

One approach is to provide an asynchronous discussion board entitled "Problems/questions/solutions" or "Ask the Instructor" (for questions directly to the instructor rather than fellow students). Another way to address the problem is to provide opportunities for informal synchronous interactions among students or between students and instructors. In a larger class, the instructor may choose to organize group work by time zone, thereby allowing multiple opportunities for smaller groups to interact in a synchronous activity. Given that required synchronous sessions are often burdensome for students in different time zones or with extensive work responsibilities, these sessions may be best made optional.

When conducting an optional, synchronous activity, it is important to facilitate the work in a manner that is conducive to an understanding among the students that their classmates may have other obligations that prohibit their participation in the synchronous event. Here too, frequent communication regarding the instructor's expectations for the student's participation can reduce the amount of conflict between group members or students who have anxiety about group work. By providing the opportunities to interact in real time, those students who have the need for feedback and interaction will take advantage of the opportunities.

Instructors Assume That Feedback to Students on Online Assignments Can Be Done in a Way Similar to Feedback in Face-to-Face Settings

Two of the main opportunities in asynchronous learning environments for formal contact between faculty and students are instructor qualitative feedback on tests or assignments and instructor comments in the class discussions. Faculty vary in how much feedback they usually provide to students, and students differ in how important detailed feedback is to them.

In addition to the need for online instructors' unspoken assumptions to be articulated as explicit expectations for students, a similar need exists for instructors to understand student expectations. Moore and Kearsley discuss student expectations about assessment. They identify the following implicit assumptions students have about assessment (Moore and Kearsley [1], page 130):

- Fair and objective grading;
- Having their work treated with respect;

- An explanation and justification of the grade awarded;
- Qualitative as well as quantitative feedback on graded assignments; and
- A clear indication of how they can improve both in terms of specific responses to questions and in general.

In this respect, instructors' grading policies and grading scales are embedded in course structure in the form of syllabi and grading rubrics. In order to align student/instructor expectations, articulating online learning expectations generically must be complemented by dialogue to achieve personal contextual relevance. Students must understand the expectations; faculty must provide personal feedback promoting that understanding and clarifying how to improve future performance in the course.

Feedback in the online setting actually serves multiple functions. For example, feedback on a test may serve not just to provide information on the students' strengths and areas for improvement, but as a way of establishing personal communication with the individual student. In a face-to-face setting, students may not express their appreciation for extensive feedback or explicitly complain about its absence. In a face-to-face setting, students who particularly need instructor contact will seek it out through informal chats before or during class or by stopping by the faculty member's office informally. These informal feedback opportunities, which do not warrant a formal appointment for discussion, are not available online. To the online learner, minimal feedback may be taken as less instructor personal interest in them, and some students may find this insufficient for their learning needs. Given that the need for informal contact may not be fully realized online, students may look for a substitute through opportunities for formal individualized contact as part of online instruction. It may be that students feel not the loss of detailed feedback on an assignment, but rather the need for more informal contact with the instructor.

Interestingly, the informal contact in face-to-face classrooms, although usually occurring outside of formal instruction time, is generally confined to the location and time of the class. Unlike office hours, which require a planned visit, the informal contact happens spontaneously. Although conducted in a public setting, the student-faculty interaction is usually a private conversation. This scenario does not transfer to an asynchronous online class unless educators use instant messaging or texting or other types of private chats to serve a similar function. Unless it is during a defined time, however, such messaging and texting could also reinforce the assumption by students of constant accessibility to the instructor. Furthermore, a defined time (like online office hours) may make multiple private chats difficult to handle simultaneously; since sequential chats are more difficult to manage online.

Students are not the only ones who miss the informal interaction. Unlike the face-to-face setting, in an online setting the main role of the educator is to structure the learning session, provide information and/or be a coach/facilitator for the students. The informal contact that occurs during face-to-face classes is difficult to replicate online. Some faculty who need that contact with students refuse to teach in an online mode or are unhappy when they do so, although they may not be consciously aware that it is the informal contact that they are missing.

Advocates of online teaching describe a variety of benefits, including richer discussions; gratification from the discussion mode of teaching; students can learn online as much as, or more than, in a face-to-face class; online teaching can bring out the best of the quieter students, etc. These and similar arguments may not make an impact, however, if the real issue for some faculty is the need for more informal contact between the instructor and student.

There are other differences in the kind of feedback delivered in synchronous and asynchronous classes. Faculty who teach in a face-to-face setting will often give the class feedback on problem areas that were common to the class. This kind of informal commentary can clarify any questions that shy students may have about their performance on an assignment. In an online setting, grading is often completed using the assignment or gradebook tool in the learning management system or course shell. This tool allows for good one-way communication between an instructor and an individual student, but lacks the advantage of sharing overall comments to a class during a synchronous session. One solution that the online educator may implement is to post summary discussion posts and comments that address and guide the entire class in their thinking about the assignments.

Another difference in online and face-to-face teaching is related to how faculty participate in class discussions. Strategies for faculty participation in face-to-face class discussion do not transfer easily to an online environment. In a face-to-face class discussion, the effective educator will be a facilitator, allowing students to discuss freely, occasionally interjecting an opinion or redirecting the discussion when needed. In an online environment, however, this type of discussion facilitation may not satisfy individual student needs for recognition and contact. The fact that students are not always aware of their need for instructor acknowledgement may lead to dissatisfaction on the part of the students, and educators who have been successful in face-to-face classrooms may be puzzled as to why their usually successful strategies are not porting to the online setting.

Given that the opportunities for the informal contact are limited in online instruction, educators may need to be conscious about providing more extensive individualized feedback or more extensive comments in discussions than they would in other settings. This does not mean that the instructor needs to continually comment on all of each student's posts. It does mean that faculty should be aware that their comments and feedback are serving a dual function: it is helpful instructionally to improve performance (as feedback should), and it serves as another means of fostering the student-instructor relationship (as does the informal contact in a face-to-face setting).

Issues Related to Expectations About Technology

The one constant in the online/distance education setting is the technology. The expectations for this technology have increased as the individual home users (in our case, the students) have access to ever improving and more powerful desktop systems. The ‘modus operandi’ of the online world is one of self-service; individual users now expect to be able to shop or bank anytime, for example.

As technology moves to take a larger role in the delivery of course content, there is less distinction between the roles of the instructor and the technology, which also means that the traditional instructor role must undergo fundamental changes. The application of these technologies by institutions of higher learning carries with it the expectation of learning anywhere at anytime. The technology now fulfills many of the roles that the instructor once held. The ability of students to access the course shell on a 24-hour basis carries with it the expectation that not only can they access the deliverables and submit assignments, but, as we said earlier, they anticipate instructor response, 24 hours a day, through email, which of course, is available all the time. In this case, the technology reinforces false assumptions students have about instructors’ availability.

In some instances, the instructor-of-record is also the student’s primary contact for the institution. Unlike a class conducted in a traditional bricks and mortar classroom, which involves the student’s passing through a physical hallway filled with offices, faculty, support staff and the other earmarks of infrastructure, the online student accesses the “institution” through a log-on page that obscures the other faculty, staff, and facilities associated with the institution. This process of limited access to the physical campus means that the student’s view of the course and college is largely limited to the individual course instructor. In this case, the instructor is the primary institutional presence.

This fundamental merging of the instructor with the technology also carries with it an expectation that the instructor has control over the infrastructure of the course shell or learning management system. Since the instructor is identified as the primary entity in the course, the instructor is held accountable when the technology fails, with a reaction similar to students being angry at a faculty member who unexpectedly does not show up for class. If an online lecture generates a ‘page cannot be displayed’ error, in the mind of the students, the lecturer has failed to deliver the content that students were expecting a time convenient to them. This is further complicated when the student’s primary access to the instructor is through email. If it takes the instructor 24 hours to respond to the student, the student may feel that the faculty member has not satisfied instructional needs in a timely manner. Although one might expect informatics students to be more tolerant of technology glitches, since they are students, they are likely to have a reaction similar to any other student.

Several options exist to mitigate the confusion over instructor role in an online learning environment. Ensuring that students have contact with the appropriate technical support staff, and reminding them of the presence of these support staff, can help to reduce anxiety when problems are encountered. Providing students with ample instruction on the technology can help ensure that students are better able to navigate through issues that may arise within the growing complexity of the online environment.

Using Online Course Structure to Reduce Transactional Distance

Michael G. Moore's (2012) theory of transactional distance (TDT) provides a framework for articulating, negotiating, and resolving unspoken assumptions into explicit expectations. Moore [2] introduced the term "transactional distance" to define the space between instructor and learner, where the concept of distance transcends geographical space to encompass a relational context defined as a dialectical balance between structure and dialog. As an example, it may be helpful to compare three scenarios: an instructor lecturing to students in an auditorium; an instructor engaging is discussion in a small face-to-face seminar course; and an asynchronous learning instructor interacting with students online. Each learning environment affords opportunities to differentiate transactional distance.

In the lecture context, there is little opportunity for dialog; the discourse is predominantly a one-way instructor monolog. Structure, in the form of the lecturer's coherent discourse as well as supplemental material such as syllabi and handouts, provides a way to account for the lack of dialogue. Even though time and space are shared synchronously, the transactional distance is potentially large.

In the second scenario, the seminar format affords opportunities for Socratic dialogue between students and instructor who are sharing time and space. As a result, the potential for dialogue to resolve ambiguity of meaning diminishes the need for structure, which lessens transactional distance.

In the third scenario, an asynchronous online class, the relationship between instructor and learner is more dependent upon a situation or context to balance structure and upon dialogue to minimize transactional distance. In this respect, the learning management system may provide structure for interaction with (1) learning technology, (2) learning content, and (3) dialogical two-way interpersonal interactions between learners, as well as between learners and instructors. In the asynchronous environment, the differences between instructor and student in terms of time and space are often large. Creating structure provides a way to reduce the need for synchronous dialogue, making learning potentially more effective and efficient by eliminating the need for the synchronous information exchange. In this respect, syllabi, bibliographies, course policies, grading rubrics, and other elements of structure impart meanings intended to preclude the need for additional explanation to reduce transactional distance. The creation of structure allows dialogue to focus on knowledge co-construction through asynchronous course discussion.

By creating structure and utilizing dialogue contextually to resolve ambiguities in meaning, the transactional distance between asynchronous faculty and students can be reduced. In this sense, transactional distance theory provides a framework for diagnosing problems rooted in unspoken assumptions, and provides a way to resolve them through the creation of structure that embeds explicit expectations for learning. Moore and Kearsley (2012) outline the expectations of, and for, asynchronous instruction. They include a table with the following functional expectations for online teaching (Moore and Kearsley [1], Table 6.1, p. 129):

- Elaborating course content;
- Supervising and moderating discussions;
- Supervising individual and group projects;
- Grading assignments and providing feedback on progress;
- Keeping student records;
- Helping students manage their study;
- Motivating students;
- Answering or referring administrative questions;
- Answering or referring technical questions;
- Answering or referring counseling questions;
- Representing students with the administration; and
- Evaluating course effectiveness.

As in face-to-face courses, online instructors create course structural elements, predominantly written textual documents, in order to minimize the potential impact of unspoken assumptions on learning. Doing so precludes the need for repetitive individual interactions and improves instructional efficiency by creating content that addresses commonly shared unspoken assumptions. By creating explicit meaning to articulate unspoken assumptions as explicit expectations for learners, online instructors create opportunities for promoting course learning as knowledge co-construction and help students learn how to learn in online environments.

We can further apply transactional distance theory as a way to make meanings explicit and facilitate learning in online environments. Unspoken assumptions are a form of ambiguity that needs clarification, negotiation, and resolution to make assumptions explicit within the learning community. Online instructors are able to create structure, making unspoken assumptions explicit, through syllabi, learning objectives, instructions for assignments, and grading rubrics. Ultimately, online meaning is embedded in written, visual, or audio text formats. The written form of text is predominant in online education, and provides opportunities for enhancing learner autonomy through dialogue. Students can clarify unspoken assumptions by posing problems and ask questions in online course forums. The process of making meaning explicit creates opportunities for resolving ambiguity, leading to better alignment of instructor and student expectations through dialogic resolutions. To promote learning, instructors take the outcomes of these negotiations and revise course structure, making expectations explicit. Much of what we have discussed in terms of unspoken assumptions has related to providing structure and explanations and making unspoken expectations explicit. This enables instructors to recognize where transactional distance may exist and to reduce it to the greatest extent possible once recognized.

Summary of Lessons Learned

Faculty must understand and manage students' common expectations and assumptions, even when these expectations and assumptions are not explicit. There is need for increased understanding and awareness of instructor and student expectations related to (1) instructor accessibility, (2) student workload, (3) feedback and participation, and (4) technology. By addressing these expectations, the instructor can achieve, if not exceed, the goals of pushing the envelope beyond the passive online experience into a level of engagement that encourages critical thinking.

Key Take-Away Points

- Recognize the implicit assumptions of faculty and students in asynchronous online courses
- Recognize that student needs and expectations for increased instructor contact may influence a variety of interactions
- Resolve ambiguity by being very explicit about course requirements, instructor expectations, and student performance
- Develop ways to reduce the transactional distance between students and between instructors and students by including more communication, more detailed feedback, forums for non-course related and other informal, discussion

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Part II
Training Informatics Specialists in the U.S.

Chapter 3
Training for Informatics Research Careers: History of Extramural Informatics Training at the National Library of Medicine

Valerie Florance

Abstract The National Library of Medicine (NLM) has been the primary funder for university-based informatics training programs in the U.S. since the early 1970s. NLM has provided institutional training grants as well as informatics research opportunities for individual fellows. The programs supported by NLM have changed over time as the competencies needed for informatics research training have evolved. Over the years the focus of the program has broadened to address a wide range of informatics needs, including the incorporation of bioinformatics and public health informatics training into programs that had earlier been focused almost exclusively on medical informatics. This chapter describes the evolution of grant-supported informatics training, identifies basic elements of informatics curricula designed to produce informatics researchers, highlights best practices in program administration, and discusses models for program evaluation that can be applied to the informatics training programs.

For 40 years, the National Library of Medicine (NLM) has been a major source of federal support for university-based training in biomedical informatics. NLM received its authority for providing training through the Medical Library Assistance Act (MLAA). Signed into law in October 1965, MLAA authorized NLM to train librarians and other information specialists. Between 1965 and 1970, about 11 % of NLM's grant budget was spent to support training [1]. By comparison in 2012, 23 % of NLM's grant budget was spent to support informatics research training. In 1971, "training for biomedical communications careers… included Master's degree programs in library science, and doctorate programs in health information research and the history of medicine. In addition, there are post-doctoral research fellowships and library internships for advanced training in information processing and medical

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_3, © Springer-Verlag London 2014

librarianship" [2]. In 2012, NLM support for informatics research training was confined to predoctoral and postdoctoral work at its university-based programs. NLM's predoctoral trainees are expected to obtain PhD degrees, and most NLM postdoctoral fellows receive an MS or PhD degree.

In the early 1970s, believing that the shortage of health sciences librarians that had led to its original training authority was no longer as severe, NLM redirected the focus of its training programs from librarian training to health scientist training in the use of computers in medical research, education and healthcare (p. 407) [3]. According to NIH grant records, in 1972 there were NLM-supported informatics training programs at Duke, Stanford, UCSF, and the University of Alabama-Birmingham, plus librarian or biomedical communication training programs at Case Western Reserve and Georgia Institute of Technology. In 1973, the Department of Health, Education and Welfare (now known as the Department of Health and Human Services) directed its agencies to end federal support for biomedical training, which reduced the flow of support to informatics training for several years. The 1978 NLM Annual Report indicates that NLM-supported training programs were now located at ten institutions:: University of California, San Francisco (UCSF), University of Alabama-Birmingham, Duke University, Ohio State University, University of Minnesota-Minneapolis, Case Western Reserve University, University of Missouri-Columbia, Mt Sinai School of Medicine, Georgia Institute of Technology and the University of Illinois Urbana-Champaign. These programs supported 71 trainees. Of the 41 predoctoral trainees, 16 sought Masters degrees and 23 sought PhDs. Two thirds of the 30 postdoctoral trainees were physicians (MDs) (pp. 50–51) [4]. The number and location of the universities providing informatics training have changed across the years, though a core group of universities has provided NLM-funded informatics research training for more than 20 years. Changes were caused by budget fluctuations and by a changing view of the programs' purposes. In the 1970s, NLM trainees were mostly physicians learning to use computers to manage health information. But in 1983, NLM saw a need to focus on research career training and a new funding announcement was issued (p. 34) [5]. As noted in the 1984 report "Research issues in the health information and health computer sciences call for highly trained, creative talent, able to articulate medicine with computers and healthcare with information science. There is a particular need in academic medicine for a new discipline – health information or health computer science. Through its training program, NLM provides grants for research career training in this field of medical informatics (p. 38)" [6]. At this time, NLM articulated the basic components of career training in informatics: … "didactic instruction, involvement in major, ongoing health computer science studies; and opportunities for work in advanced information science research" (p. 38) [6]. Five programs received funding as a result of this new offering: UCSF, Minnesota, Harvard, Tufts-New England Medical Center and Stanford. Over the ensuing years, NLM supported as many as 18 separate programs. Most recently, as of July 1, 2012, 14 programs received new 5-year awards for training of 108 predoctoral, 79 postdoctoral and 31 short-term trainees, plus 9 pre- and postdoctoral dental informatics trainees funded by the National Institute of Dental and Craniofacial Research [7].

Two of these programs were from the group of five funded in 1984 and seven of the current NLM programs have been providing NLM-supported informatics training for more than 20 years.

Evolving Scope of NLM's Informatics Training Programs

Beginning in 1996, NLM's funding announcements provided flexibility for applicants to suggest specialized training possibilities, including special support for librarians, cancer informatics and dental informatics (in the latter cases, other NIH Institutes provided funds for specialist training at NLM-funded programs). In 2001, in the midst of the doubling of the NIH budget, NLM expanded the scope of informatics training, noting that "NLM is aware that informatics has historically had a heavy focus on clinically relevant topics, and that healthcare delivery continues to offer a rich variety of important research questions for informaticians. However, the remarkable emergence of very large datasets in genomics, neuroscience, clinical research, health services research and other domains has resulted in a rapidly expanding interest among basic and clinical scientists in the potential of informatics for facilitating research and for creating knowledge. NLM believes there will be high demand for specialists capable of applying informatics to biomedical research. Core training for informaticians should include exposure to the informatics of biomedical research" [8]. This emphasis of NLM led to an infusion of bioinformatics into what had been solely clinical informatics programs (see also Chap. 11). As a result, many informatics programs added new faculty who could teach this material.

In the 2006 funding announcement, applicants were strongly encouraged to require a degree from most trainees, including postdoctoral fellows. Four thematic training domains were proposed, healthcare/clinical informatics; bioinformatics and/or computational biology, clinical research and translational informatics, and public health informatics. In addition to addressing at least one of these areas, applicants could propose specialized tracks in education of health professionals, imaging and signal processing, health services research, or another area if pre-approved by NLM. Most of the successful programs offered at least two of the main domains, such as healthcare/clinical and public health, while some offered all four. Few proposed specialized tracks [9].

In the most recent solicitation, issued in 2011, NLM used the four informatics tracks used by the American Medical Informatics Association (AMIA) as the core areas for informatics research training, developing a brief definition for each:

- Healthcare/clinical informatics (HCI): Applications of informatics principles and methods to direct patient care, such as advanced clinical decision support systems and multimedia electronic health records, to the provision of informational support to healthcare consumers. Special tracks might be offered for nursing informatics, dental informatics, imaging informatics, or other appropriate clinical themes.

- Translational bioinformatics (TBI): Applications of informatics principles and methods to support 'bench to bedside to practice' translational research, such as genome-phenome relationships, pharmacogenomics, or personalized medicine. Special tracks might be offered in health effects of environmental factors, genome-wide association studies (GWAS), or other similar areas.
- Clinical research informatics (CRI): Applications of informatics principles and methods to support basic clinical trials and comparative effectiveness research. Special tracks might be offered in areas such as biostatistics, in-silico trials, merging and mining large disparate data sets that mix images, text and data.
- Public health informatics (PHI): Applications of informatics principles and methods to build integrated resources for health services research, for decision support in public health agencies, to support regional or global health research, or syndromic surveillance. Special tracks might be offered in areas such as health literacy, information design for consumers, health effects of climate change [10].

Using the NIH Guide to Track the Evolution of Informatics Research Training

The NIH Guide to Grants and Contracts is a regular issuance of all new funding announcements offered by the National Institutes of Health. Announcements of new competitions for NLM-funded university-based research training are published there, every five years. In a sense, the funding opportunity announcements published in the NIH Guide to Grants and Contracts provide snapshots of the evolution of informatics research training supported by the National Library of Medicine. For example, in 1996, the purpose was stated this way: "Such training will help meet a growing need for qualified, talented investigators, well prepared to address information problems in healthcare, health profession's education, biomedical research, health services research, and public health" [11]. The 2001 issuance states it this way: "Graduates of the NLM-supported programs should be able to conduct basic or applied research at the intersection of biology and medicine with computer and cognitive sciences, and are expected to be familiar with the use and potential of modern information technology" [8]. In 2006, applicants were told: "Such programs help meet a growing need for investigators trained in biomedical computing and relevant application domains including healthcare delivery, basic biomedical research, clinical and translational research, public health, health information sciences and other related areas. Informatics training is multi-disciplinary. This initiative is not intended to prepare trainees for careers emphasizing planning, deployment, maintenance, or administration of computer systems in healthcare, public health, medical education or research. The emphasis in this program is on the development of new knowledge that advances informatics as a scientific discipline" [9].

In the most recent announcement for NLM training programs, issued in 2011, the purpose statement noted that: "Graduates of the NLM-supported programs should be able to conduct original basic or applied research at the intersection of computer and information sciences with one or more biomedical application domains. Successful graduates of these programs will be prepared for research-oriented roles in academic institutions, not-for-profit research institutes, governmental and public health agencies, pharmaceutical and software companies, and healthcare organizations. This initiative is not intended to prepare trainees for careers emphasizing planning, deployment, maintenance, or administration of computer systems in healthcare, public health, medical education or research. The emphasis in this program is on the development of new knowledge that advances informatics as a scientific discipline" [10].

NLM's funding announcements document the scope of informatics training at points in time. But in the years between grant competitions, NLM sometimes expanded the scope of training by awarding grant supplements to the existing programs. Following the issuance in 1999 of the Biomedical Information Science and Technology Initiative (BISTI) report [12], NLM awarded supplemental funds in 2000 and 2001, to its existing training programs, to support development of resources for training bioinformaticians. In these years, supplements were also awarded to NLM training programs to strengthen offerings relating to health services research (pp. 68–69) [13]. In 2005, the Robert Wood Johnson Foundation awarded a grant to NLM to support the development of public health informatics as a research career (p. 59) [14]. As a result, four NLM training programs received supplemental support to fulfill the objectives of this initiative, and several that did not receive funds implemented tracks for public health informatics.

In summary, the field of informatics has evolved gradually over decades, as observed through the prism of NLM's informatics training programs. From the idea that computers could help physicians with health information management, informatics as a scientific domain now has multiple subfields of interest ranging from clinician decision support to computational modeling of disease processes to global monitoring of disease outbreaks to patient-controlled health records to information interfaces for low literacy populations.

Although university-based programs have been NLM's core strategy for training a cadre of informatics researchers, at times since 1972, NLM has also supported extramural informatics training for individuals, and a number of other NIH institutes employ individual fellowships as a mechanism for research training. Between 1989 and 2005, NLM awarded dozens of individual fellowships for research or applied informatics to individuals not enrolled at one of NLM's university-based programs. For example, in 1992 NLM announced an individual applied informatics fellowship program, noting in the announcement that "If informatics is to realize its full potential as an indispensable tool for researchers and health-care workers, there must be adequate number of health professionals able to apply the knowledge of informatics to develop modern information systems in traditional organizations, use the new information techniques in a specific field, and help disseminate promising programs and systems" [15]. Although NLM does not currently offer individual fellowships, the NIH Advisory Committee to the Director, Biomedical Workforce Task Force [16] recently recommended that all components of NIH offer individual predoctoral fellowships for research training. Implementation of this recommendation, planned for 2014 and 2015, will provide expanded access to individual fellowships for informatics training.

While NLM has been the primary source at NIH for informatics funding, other Institutes have training grant programs or fellowships that encompass informatics elements focused in a particular domain. For example, the National Institute of General Medical Sciences offers predoctoral training in bioinformatics and computational biology and in biostatistics. The National Institute of Biomedical Imaging and Bioengineering offers training in Imaging and Information Sciences. The National Cancer Institute offers individual fellowships which support research in a clear cancer focus area. The NIH Guide [17] and the home web sites of the 24 NIH Institutes and Centers that make awards [18] provide greater detail on the scope and focus of such informatics-related training.

Data Requirements for Training Grant Applications

Every application to NIH for training funds, whether from NLM or another Institute, requires a detailed data set reflecting institutional resources and readiness to train top quality biomedical researchers. Three elements of any Funding Opportunity Announcement (FOA) or Request for Applications (RFA) related to institutional training provide the interested applicant with insight into the critical content elements.

Description of the Funding Opportunity

This section gives the basic outline of the type of training program, levels of trainee to be supported, the offeror's rationale for investing in training and, sometimes, what is not covered by the offering. In NLM's most recent offering (RFA-LM-11-001), the description section provides guidance on the different areas of informatics training that could be proposed, the fundamental elements of the curriculum, (e.g., core curriculum plus a range of electives); the support, both technical and human a trainee should receive (e.g., meaningful, supervised research experience); and the intended product of training (e.g., independent research compatible with publication of results and competition for grants). Expected endpoints of training are also listed, as are options for specialized training themes or tracks [10].

Research Program Plan

In RFA-LM-11-001, this section provides a more detailed picture of expectations regarding program administration (e.g., administrative home of the program); faculty (both core and collaborating faculty); and proposed training (e.g., long term objectives of the program and strategies for carrying them out. Specifications include details about core curriculum, practicum experience, elective options and trainee research experience); evaluation plan for the program as a whole and for individual trainees; pool of candidates; institutional environment, including an estimate of other similar trainees at the institution. Reviewers scrutinize this section for evidence that applicants have thought out the details, have a strong curriculum and rich environment with collaborating faculty from other departments, and have past success at training. Reviewer analysis of the research program plan is done in conjunction with the data tables required in all training grant applications (Tables 1–10 for new applications, Tables 1–12 for renewals) [10].

Data Tables for Training Grant Applications

All NIH training grant applications use the same data tables to provide reviewers and grant program staff with evidence about the program's past success and/or likelihood of future success. The tables collect detailed evidence in the following areas: participating departments/programs and faculty; other institutional training grants in the participating units; grant support of participating faculty; pre- and post-doctoral trainees of participating faculty; publications by pre- and post-doctoral trainees; admissions and completion records for participating organizations; qualifications of recent and current applicants; admissions and retention of underrepresented populations. Previously funded programs must also submit tables covering pre- and post-doctoral trainees supported and their current status. Careful thought should be given to these tables in light of the proposed plan. For example, thoughtful selection of collaborating departments and faculty could strengthen an application. Reviewers have a keen eye for data that do not resonate with the textual content. NIH provides an extensive set of templates and instructions for these tables. An application missing these data will not review well, so devoting time to gathering and reviewing tabular information in advance is a wise investment.

Scored Review Criteria

All grant solicitations, training or otherwise, include lists of scored criteria and additional review criteria. The former affect the overall impact score, the latter do not with one exception. Although it seems obvious, the importance of addressing scored review criteria within the body of the application cannot be overstated. In RFA LM-11-001, review criteria are listed as questions. An applicant should know where the answers are to these questions in his/her application. Having an outside reader try to answer them might be a useful pre-submission exercise, to assure that all points are well-covered. Among the additional review criteria, most are not applicable to training grants. However, if there is a section called "Renewals", applicants who are seeking a new round of funding for their existing training grant should be certain that these questions are answered in addition to those listed in the scored review criteria section. These added questions relate to how well the applicant performed in the past funding period. Reviewers look carefully at renewal applications and will assign poorer scores to those that do not show strong results.

Model Training Program for Biomedical Informatics

While NLM has never dictated the specifics of curriculum content or program structure for the research training it supports, funding competition announcements have always enumerated the important factors to be incorporated into a research training plan. These always include:

1. Interdisciplinary content, with coverage of information science, cognitive science and knowledge of one or more domains of biomedicine
2. A core curriculum of required courses emphasizing informatics concepts and methods and state-of-the-art technology assessments
3. Electives providing opportunities for advanced training in informatics fields
4. Individual research experience for each trainee, including assistance for trainees in selecting appropriate research projects
5. Exposure to the informatics of basic biomedical research
6. Effective programs for recruiting and retaining a diverse pool of trainees
7. Approaches for evaluating program success

During a project to develop and revise NLM's overall training program evaluation framework, data were extracted from more than a dozen training programs over 15 years of training experience. Analysis yielded patterns of activity that characterize successful programs [19]. They are framed below as four program objectives for a model training program.

1. Produce researchers prepared to conduct independent research in biomedical informatics by the time they complete their training.

Key to a successful training program in informatics is attracting and retaining a diverse group of trainees. For some programs, trainees are selected from a pool of outside applicants. For others, they are selected from the University's matriculated graduate student population (the latter approach is most common in biological sciences areas such as bioinformatics or computational biology). Although some fields assume that new PhDs will obtain postdoctoral training, this is not always the case in biomedical informatics. For example, a study of NLM trainees who graduated between 1991 and 2005 showed that about 15 % continued their training through postdoctoral appointments, residencies or additional graduate degrees (Table 42, p. 65) [20]. An evaluation metric for this area might be that 95 % of graduates have obtained a suitable position, a career transition award or entered postdoctoral training within 1 year of completing planned training.

Outside funders usually have time limits for support of graduate training. For example, NLM provides up to five total years of support for predoctoral training, or three years of postdoctoral support. A recent report of an NIH Biomedical Workforce Task Force recommends no more than five years of total support for graduate training [16], a reduction of what has been allowed in past years. While all universities have multiple sources of support for their graduate students, good management practice suggests that programs which depend heavily on outside funding should be setting some numeric targets within the institution, such as 90 % of predoctoral trainees complete their planned training within five years.

2. Provide state-of-the-art informatics curriculum content, successful research mentors, research practicum opportunities to a diverse group of trainees during the training period.

This objective involves multiple tasks and targets. Establishing a continuous program of curriculum review and renewal means setting a threshold, such as 25 % of courses are refreshed each year, or one new course every two years. A plan for dropping or replacing courses would be part of this process.

In its funding solicitation of 2006, NLM characterized a core curriculum as curriculum "addressing informatics concepts and methods that support the entire program, spanning all application domains that are addressed….the preponderance of courses and other educational elements comprising the core must apply to all application domains." Applicants were required to provide details about component courses and educational experiences [9].

All of NLM's university-based training programs offer a core curriculum of required courses plus an extensive menu of elective courses, often housed in collaborating departments such as computer science or business or molecular biology. All offer at least one core course in the basic principles and concepts of informatics. For the university-based training programs funded by NLM in 2006, the most common required courses (in addition to the core course) include quantitative methods (69 %) and techniques of computer science, engineering or other information fields (75 %), biological sciences (50 %), ethics (50 %) and research methods (50 %) [20]. When prerequisites are required, as they are at several programs, they are typically courses in computing or quantitative methods. Many programs require more than one core course, so that the subfields of informatics can be covered in greater detail. The number and scope of required courses reflects the philosophy of the program director – some programs are tightly structured into tracks, while other allow a trainee to tailor the coursework plan for research area that interests her/him.

Engaging faculty in a way that advances their own work as well as those of the trainees requires action at several levels. New faculty should receive some kind of training in mentoring and/or have mentors of their own. If a target is set that 100 % of trainees in translational bioinformatics have access to dual mentors, then the dual mentors will need to learn this role. Targets should be established for faculty publishing and research activities such as 90 % of faculty have outside funding for their research and peer-reviewed publications in their research area. Programs should provide mentorship training to faculty who will be mentoring the trainees.

To establish standards for increasing diversity in the trainee pool, targets might be established for each type of intervention, such as to attend two minority-focused recruitment meetings per year or offer at least three short-term research experiences for underrepresented groups. NIH requires all training programs to offer in-person training for Responsible Conduct of Research (RCR) to 100 % of their trainees. Many universities developed online learning for this training, but NIH requires in-person RCR training as well, so targets must be set for in-person experiences too, such as introducing a case study that fulfills RCR requirement into all core courses.

A recent report of the Biomedical Task Force of the NIH Advisory Committee to the Director reported that NIH trainees were occupying an array of science-related positions, rather than solely occupying academic-style tenure track positions. They recommended that "NIH should create a program to supplement training grants … to allow institutions to provide additional training and career development experiences to equip students for various career options" (p. 8) [16].

In the past, the expectation for a biomedical research trainee supported by NIH was that she/he would graduate, obtain an academic position, and begin to apply for research project grants from NIH. The Task Force report acknowledges that only about 43 % of NIH research trainees follow that path, and asserts that science-related careers, in government, in industry and public policy, can be as important to the advancement of science as academic pursuits (see Figure 19, p. 32) [16].

Studying its own trainees in 2008, NLM found that about 40 % held faculty positions, 21 % were working in industry or self-employed in small businesses, 16 % worked in healthcare organizations, 15 % were still in training, and the rest worked in government agencies or other non-profit organizations (Table 42, p. 65) [20]. Additionally, a pattern emerged suggesting that across their careers, informaticians often move back and forth among these options. An important lesson to be drawn here is that curriculum planners should think about the underpinnings of a research career broadly, and prepare trainees for administrative and managerial roles as well as for research. For example, in 2010, when NLM provided curriculum development funds to its university-training programs, the program at Rice University created an online course covering topics such a lab management and grant writing [21], and several other programs offer electives in these areas.

3. Advance knowledge in the field of biomedical informatics during and after the award period.

Funding agencies are increasingly focused on measuring the outcomes and impact of the grants they award. The area of advancing knowledge is often measured bibliometrically, using publication and citation rates. Bibliometric methods are limited in their ability to capture the full range of informatics trainee contributions. Analysis of 200 peer-reviewed articles published in 2012 by NLM grantees shows that 34 % of the articles cite training grant numbers, but several programs not represented indicated that their trainees had, indeed, published articles. One reason for this is that peer-reviewed publications or other dissemination venues that don't include the grant number in an acknowledgement are difficult to identify. Another is that commercial resources available for bibliometric analysis, such as Scopus or Web of Science or Google Scholar don't cover the full range of journals in which informaticians publish. Nevertheless, training program directors can set targets for this area such as 95 % of trainees author or co-author a peer reviewed article that is published or accepted for publication and 100 % of trainees make at least one presentation of their work at a national meeting.

Software, datasets or knowledge resources produced by informatics researchers are not easily identified by bibliometric methods, and there are no widely accepted metrics for these types of contributions. Implementation planning at NIH for recommendations from the Advisory Committee to the Director's Working Group on Data and Informatics includes developing approaches for identifying and citing datasets and knowledge resources that could be important to informaticians [22]. When such resources are catalogued, it will be easier for trainees to cite their contributions and for programs and funders to monitor performance.

4. Demonstrate administrative competence through program management and evaluation.

Every training program must undertake regular evaluation of the entire program as a whole. In NLM's current group of training programs, two types of internally sponsored program evaluation are most common. Several programs have an external advisory group that meets every year and provide advice to them. In some universities, the graduate school has a regular five year cycle in which the university brings together a committee to evaluate the program. Peer review of a training grant proposal can provide valuable extramural assessment of proposed curriculum and activities.

In addition to overall evaluation, training programs must establish evaluation metrics for each type of training activity. Approaches taken for establishing trainee evaluation metrics vary by university, but each NLM-funded program employs such metrics, which often involve course completion, academic achievement, publications, presentations, awards and evidence of leadership. Some programs employ explicit core competencies for each curriculum component. The recently-issued AMIA Academic Forum report provides an excellent starting place for a university considering a program in biomedical informatics training, providing both a definition of biomedical informatics and a set of competencies to drive core curriculum [23].

Establishing a personal training plan for each trainee and providing career counseling and other resources to assist them in the transition from training to career are fundamental activities of a model program. The Biomedical Workforce Task Force Report noted a lack of consistency in the mentoring provided in the training models supported by most individual NIH Institutes. Training supported by other NIH Institutes falls under the National Research Service Award (NRSA) rules. For a typical NRSA predoctoral trainee in molecular biology, two years of predoctoral support through a T32 training grant would be followed by several additional years supported as a graduate assistant paid by the research grant(s) of a mentor/investigator. For trainees in this model, the Task Force felt that individual development plans, career counseling and tracking of trainee accomplishments needed strengthening (pp. 8–9) [16]. NLM's training programs, which are not part of NRSA, employ a different strategy for trainee support, one that does not have these deficiencies. NLM provides funding for up to five years of predoctoral training through the training program itself, so that trainees work with their mentors over an extended period. Typically, trainee progress is evaluated twice each year, in writing, by the faculty mentor, based on a training plan worked out at the beginning of a trainee's learning program.

Programs must also have methods to track trainee accomplishments and make that information available to prospective trainees. Another planned NIH initiative based on recommendations in Reports of the Biomedical Workforce Task Force and the Working Group on Diversity in the Biomedical Research Workforce involves developing a tracking system for trainees who have been supported by federal funds, so that long term career development and publication patterns can be analyzed, and future grant applications can be simplified by pre-filling certain fields [16, 24]. It is felt that this will deliver value to both the funder and the training organization, as universities can use this information to recruit future trainees. To date, there is no single system used in universities to track students in this way. CareerTrac, a tracking system developed by the National Institute of Environmental Health Sciences and the Fogarty International Center, is being implemented by NLM's informatics training programs in 2013. CareerTrac [25] allows easy linking of trainees with papers listed in Pubmed and training information in their appointment forms, and allows tracking of awards, presentations and career steps. CareerTrac, or a system based upon it, will likely be implemented for all NIH training programs in the next three years.

Recruitment and retention of a qualified, diverse group of trainees has always been a criterion for success listed in NLM's grant funding announcements for informatics training. The 2011 solicitation stated: "This FOA requires that all applicants submit a diversity recruitment and retention plan. While applicants may base their plans on multi-disciplinary programs in place at their institutions, they must also indicate how the informatics programs will participate in these recruitment activities and how these activities will meet the needs of potential applicants with interests in informatics" [10]. Reporting on past success at minority recruitment is a requirement of all NIH training grant applications (Table 10). Among NLM's programs, strategies include offering special summer programs; attendance at regional and national meetings such as the American Indian Science and Engineering Society or the Annual Biomedical Research Conference for Minority Students; partnership with one or more minority-serving universities, tribal colleges or historically black colleges and universities.

Evaluation Framework for NLM's Extramural Training Program in Biomedical Informatics

In 2007, working with Humanitas, a management and technology consultant, NLM grant program staff developed a framework for overall evaluation of the informatics research training programs sponsored by NLM [20] (Appendix B). Beginning with the program goals stated in NLM's early funding announcements, three training program objectives were framed, standards and indexes were established for each objective, and data points identified that would indicate the level of success. The three initial objectives were: Increase the number of researchers trained to conduct independent research in the field of biomedical informatics; Develop and increase institutional training capacity for the field of biomedical informatics; Advance knowledge in the field of biomedical informatics. The example below shows the development of this concept for one objective.

Objective 1: Increase the number of researchers trained to conduct independent research in the biomedical informatics field during the award period.

Standards for objective 1:

1. *Standard*: Nearly all trainees successfully complete the program. Index: 90 % of trainees complete the program
2. *Standard*: Most trainees embark on careers in biomedical informatics research or continue their education. Index: 75 % or more continue in a career or obtain additional graduate training.
3. *Standard*: The majority of graduates of NLM's university-based programs are still pursuing research careers five years after completing their training. Index: 50 % or more are in a research job five years after completing training
4. *Standard*: All trainees have mentors. Index: 100 % have mentors
   (a) Who actively conduct research in informatics. Index: receive grant during the award period.
   (b) Who have experience as a mentor.
   (c) Who engage the trainee in substantial research projects. Index: co-author of papers.

After establishing the draft evaluation framework, data were extracted from 17 grant applications received in 2001 and 2006, along with available progress reports during that period. Analysis demonstrated that NLM's training programs exceeded the proposed benchmarks in many areas, and that data were not available for some candidate benchmarks. Highlights of the findings for Objective 1:

- 93.5 % of NLM's trainees supported between 1991 and 2005 completed their training ($n = 693$)
- 76 % were still in the field in academic, industry or healthcare positions, based on position titles. Former postdoctoral trainees were more likely to be faculty members (44 % compared to 31 % for predoctoral trainees). About 15 % were pursuing additional training. Others were in government or other agencies.
- The majority of trainees (82 % in 2001, 61 % in 2006) had mentors who were principal investigators of active research grants, and 74.9 % of those who had published had published with their mentor.

After going through each objective and the findings, the evaluation framework's standards and index measures were adjusted. In some cases, a standard was restated due to the unavailability of reliable index data. Any recipient of an NIH training grant can be assured that some similar evaluation framework is being used by the funding agency both at the individual award level and the programmatic level.

Summary

Training for careers in biomedical informatics has entered its fourth decade at NLM. From its early roots in healthcare information management, the field of biomedical informatics evolved and grew into an academic discipline with many distinct subdomains. Today, biomedical informatics trainees include physicians, biologists, nurses, public health administrators, librarians, computer scientists and many others. Graduates move into careers in academic centers, industry, government, small business and other public and private agencies. NLM's experience with its programs and their graduates suggests that the most successful informatics training programs have these qualities:

- Offer courses and experiences that address the broad array of skills and knowledge that can apply to different types of biomedical informatics careers
- Update course content and teaching methods regularly, including use of teaching technologies and self-guided learning as appropriate
- Require didactic, quantitative and computational elements, plus practicum experience for every trainee
- Provide easy access to training in management skills such as budgeting, grant writing or managing a research team
- Have core faculty who employ hands-on mentoring that involves face-to-face meetings, annual written evaluations and career counseling. Provide dual mentors when feasible or needed for the trainee's research
- Form collaborations that provide synergy for program goals, with collaborating faculty in relevant academic departments, business or government who can teach and mentor informatics trainees
- Offer 'identity-building' group experiences for their trainees, such as joint retreats, journal clubs and required participation in speaker series. This is especially important if trainees are located in several academic departments or if they are in distinct tracks within a department.
- Require trainees to make regional or national presentations and write peer-reviewed publications during their training period.
- Gather data in an ongoing way that are useful for evaluation and tracking of individual progress, of curriculum quality, faculty strength.
- Arrange for external evaluation of the academic program on a regular basis, at least every five years

Key Take-Away Points

Features of strong Informatics programs:

- Interdisciplinary content, with coverage of information science, cognitive science and knowledge of one or more domains of biomedicine
- A core curriculum of required courses emphasizing informatics concepts and methods and state-of-the-art technology assessments

- Electives providing opportunities for advanced training in informatics fields
- Individual research experience for each trainee, including assistance for trainees in selecting appropriate research projects
- Exposure to the informatics of subdomains such as public health or bioinformatics
- Effective programs for recruiting and retaining a diverse pool of trainees
- Approaches for evaluating program success

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Chapter 4
Clinical Informatics Subspecialty Certification and Training

Reed M. Gardner and Charles Safran

Abstract Although the clinical informatics subspecialty is new, the term "clinical informatics" first appeared in the informatics literature in 1983 in an article in the Proceedings of the American Association for Medical Systems and Informatics (AAMSI) Congress by Michael A. Jenkin entitled "Clinical specialty systems as an introduction to Clinical Informatics." Over the succeeding years there has been a great deal of research and development in clinical informatics, and at least a decade of effort to form the subspecialty. Finally, in 2011 the discipline was first recognized as a subspecialty by the American Board of Medical Specialties and the first specialty board certification examination was in 2013. This chapter describes the background about the development of the subspecialty as well as the core content and training requirements.

History and Background of Clinical Informatics

The term "clinical informatics" first appeared in the literature in the Proceedings of the American Association for Medical Systems and Informatics (AAMSI) Congress in 1983 in an article by Michael A. Jenkin entitled *Clinical specialty systems as an introduction to* ***Clinical Informatics*** [1]. Jenkin also published a second article; ***Clinical Informatics***: *a strategy for the use of information in the clinical setting*

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_4, © Springer-Verlag London 2014

which appeared in 1984 [2]. The field of clinical informatics was not new and had been evolving for at least a century. Perhaps the first clinical informatician was Florence Nightingale who introduced classification to field injury during the Crimean War in 1854. Herman Hollerith developed and received his PhD from Columbia University in 1889 with a dissertation entitled "An Electric Tabulating System" which used the punched card. The system was a key technology used to assist in taking the 1890 census.

In 1959 Robert S. Ledley and Lee B. Lusted published a key article in Science entitled, "*Reasoning foundations of medical diagnosis*; *symbolic logic*, *probability*, *and value theory aid our understanding of how physicians reason*" which became a cornerstone of computerized medical reasoning [3]. In the 1960s, in the United States, several medical investigators made use of computers to improve the practice of medicine. Homer R. Warner [4, 5] and colleagues at LDS Hospital in Salt Lake City developed mathematical approaches for medical diagnosis as well as a clinical information system called HELP [6]. Donald A. B. Lindberg developed the first automated clinical laboratory system [7]. Morris F. Collen developed automated multiphasic screening at Kaiser-Permanente in northern California [8]. G. Octo Barnett [9], Robert A. Greenes [10], and colleagues at the Massachusetts General Hospital developed the MUMPS (**M**assachusetts General Hospital **U**tility **M**ulti-**P**rogramming **S**ystem – also known as **M**) computer programming language and used mini-computers to develop the COSTAR patient care system. Warner V. Slack developed a computer-based history taking system [11] and his life-long colleague Howard L. Bleich developed methods for interpreting acid–base disorders [12]. These two physicians and their colleagues then went on to develop a multitude of clinical computer applications at Harvard and Beth-Israel Hospital in Boston.

In the 1970s a large group of individuals and clinical systems were developed. Donald W. Simborg added another medical history taking system [13]. El Camino Hospital in California developed automated medical records [14]. William W. Stead and W. Edward Hammond developed clinical computing systems at Duke University [15]. Edward H. Shortliffe developed the MYCIN computer-based infectious disease consulting system at Stanford University [16]. Clement J. McDonald used protocol-based computer reminders to improve the quality of patient care and compensate for the "non-perfectibility of man" [17]. In 1974, Francois Gremy coined the term "medical informatics" to encompass these types of activities [18, 19].

The success of these early pioneers led to funding of individual clinical computing systems, development of clinical computing research laboratories, and eventually to the National Library of Medicine funding training programs in the growing field which eventually became a much broader field known as "Biomedical Informatics." Biomedical Informatics includes clinical informatics, bioinformatics, public health informatics and other topics [20]. The training focus and curricula of each of these academic programs varied, but a next generation of informaticians was minted who were instrumental in further developing these seminal systems and in starting new clinical computing systems development (See also Chap. 3 for more details on the NLM training programs).

The past few decades have been exciting and challenging times for the clinical informatics field. After a gestation period of over 50 years, the Electronic Health Record (EHR) has become a reality in many healthcare facilities in the United States [20]. Clinicians, technologists and politicians have jointly decided that it is inevitable that widespread adoption of the EHR will improve caregivers' decisions and patients' outcomes [21]. In 2004, the Office of the National Coordinator (ONC) for Health Information Technology was created within the U. S. Department of Health and Human Services (DHHS). The primary focus of ONC is to facilitate the implementation and use of Health Information Technology (HIT) to improve the efficiency and quality of Healthcare. Based on efforts of the ONC, the U.S. Congress and the Obama Administration in 2009 enacted the Health Information and Technology for Economic and Clinical Health (HITECH) Act [21–23]. HITECH calls for the Secretary of DHHS to develop specific "*meaningful use*" objectives for EHRs and have the EHRs certified. The primary intent of having an EHR which meets "meaningful use" objectives is to improve care quality [21]. Already Stage 1 and Stage 2 "meaningful use" objectives have been developed and promulgated.

Development of Clinical Informatics Specialty Board Certification for Physicians

There are over 750,000 physicians in the United States as well as millions of nurses and pharmacists who will be using EHR systems. In 1995, the American Nursing Association (ANA) recognized nursing informatics as an important area of clinical specialization and established a method for nursing informatics certification [24–26]. As part of the process, in 1995, ANA published a document entitled *Nursing Informatics*: *Practice Scope and Standards of Practice*. The latest revision of that document describing certification of nursing informatics was published in 2007 [27].

In 2003 the Institute of Medicine issued a report *Health Professions Education*: *A Bridge to Quality* [28]. This report called for health professionals to be trained to use informatics and related tools to "reduce errors, manage knowledge and information, make decisions and communicate more effectively than had been the case in the past."

In 2004, then President George W. Bush set a national goal that the majority of people in the United States should have their health information in Electronic Health Records (EHRs) by 2014. In response, Charles Safran, then Chairman of the Board of Directors of the American Medical Informatics Association (AMIA), called for the training of one physician and one nurse for each of the nearly 6,000 hospitals in the United States to help implement EHRs [29]. During 2005, AMIA along with the American Health Information Management Association (AHIMA) convened a policy summit meeting to examine the workforce implications of then President Bush's directive [30]. Participants in the summit identified three key success factors for achieving the presidential directive:

1. The need to invest in people to use technology wisely and well
2. The need for a core of health information specialists who were academically prepared
3. The need for new educational curricula and learning environments

The AMIA/AHIMA summit participants estimated that over 50,000 healthcare professionals would need some level of informatics training to support the proposed national health information infrastructure. Not only were there physicians and nurses who needed training but also other health information management professionals (medical records and office management staff) who would need to enhance their clinical informatics skills.

An informal survey of National Library of Medicine biomedical informatics training program directors revealed that almost none of their training programs had the capacity to help meet the perceived huge physician and other healthcare professional workforce deficit. However, Dr. William Hersh, at Oregon Health Sciences University (OHSU), had developed capabilities for distance education for his graduate education program and suggested that this approach could be used to address workforce development [31]. In consultation with Don E. Detmer, President of AMIA and Charles Safran, Chairman of the AMIA Board of Directors, AMIA initiated its 10×10 program with the goal of training 10,000 physicians and nurses by 2010 with OHSU being the first AMIA 10×10 site.

The intent of the AMIA 10×10 programs was to initiate clinical informatics training with a one semester graduate level introduction of the application of informatics to clinical healthcare. The program was open to all students and health professionals interested in an introduction to information and communication technologies in healthcare. AMIA hoped that some of the 10×10 participants would go on to obtain more formal training in the field of informatics (see also Chap. 8 for more information on AMIA 10×10).

During AMIA's fall meeting in 2004, Detmer and Safran convened a "Town Hall" meeting to discuss AMIA's role in workforce training in clinical informatics. The Town Hall discussion reached three important conclusions:

1. Informatics as a discipline is broader than clinical informatics.
2. Clinical informatics is an inter-professional domain that helps to integrate health professions.
3. Sufficient social value in clinical informatics exists to ensure benefit from formal training and certification.

The AMIA Board of Directors subsequently adopted a formal policy and approved an effort to obtain funding to undertake formal development of clinical informatics certification for clinical professionals beginning with physicians.

In March 2007, the Robert Wood Johnson Foundation awarded a grant to AMIA to support the development of the documents required by the American Board of Medical Specialties (ABMS) to create a new medical subspecialty in clinical informatics [32, 33].

Creating the Medical Subspecialty of Clinical Informatics

The American Board of Medical Specialties was established in 1933 and is a non-profit organization of "Member Boards", representing 24 broad areas of specialty medicine. ABMS is the largest physician-led specialty certification organization in the United States. ABMS Member Boards maintain a rigorous process for the evaluation and Board Certification of medical specialists. They certify specialists in more than 150 medical specialties and subspecialties. More than 80 % of practicing physicians in the United States have achieved Board Certification by one or more of the ABMS Member Boards. The Member Boards of ABMS also support lifelong learning by physicians through the ABMS Maintenance of Certification (MOC) program [34, 35].

The two documents required by the ABMS for review to determine whether clinical informatics was indeed a new medical specialty were – the **Core Content** of the curriculum and the **Clinical Training** Program. AMIA established two working teams to provide the needed documents. AMIA also hired a consultant (Benson S. Munger) who had recently completed the submission of similar documents required for another clinical field. A professional Editor (Elaine B. Steen) prepared documents and agendas for both teams. The Core Content team met three times between August 2007 and January 2008 [36]. The Clinical Training team met three times between January 2008 and August 2008 [37]. In addition to these face-to-face meetings, there were multiple Email conversations and telephone conference calls to establish consensus in the required documents.

Development of the Core Content

The core content working team consisted of professionals who had been working in the field of "clinical informatics" and included physicians, computer scientists, engineers, nurses and other technologists. The Core Content for a medical subspecialty defined the boundaries of the discipline and helped inform clinical informatics fellowship training program requirements. Under the leadership of Reed M. Gardner, an engineer/clinical informatician as Chair and J. Marc Overhage an internist and clinical informatician as vice-Chair, a team of 11 experts established that clinical informatics encompassed three spheres of activity [36]:

1. Clinical care
2. The healthcare system and
3. Information and communication technology.

The Core Content team decided both what the discipline should be called and what the discipline encompassed. Initially the team considered naming the subspecialty "applied clinical informatics" . However after a lengthy discussion, the team decided that the term "applied" was redundant and that the discipline should be called clinical informatics. The team defined what clinical informaticians do as: *Clinical informaticians transform healthcare by analyzing*, *designing*, *implementing*, *and evaluating information and communication systems that enhance individual and population health outcomes*, *improve patient care*, *and strengthen the clinician-patient relationship*. *Clinical informaticians use their knowledge of patient care combined with their understanding of informatics concepts*, *methods*, *and tools to*:

1. *Assess information and knowledge needs of healthcare professionals and patients*,
2. *Characterize*, *evaluate*, *and refine clinical processes*,
3. *Develop*, *implement*, *and refine clinical decision support systems*, *and*
4. *Lead or participate in the procurement*, *customization*, *development*, *implementation*, *management*, *evaluation*, *and continuous improvement of clinical information systems* [36].

The key concepts were that physicians who are clinical informaticians must measurably improve care or care processes and that they must have the skills to collaborate with a wide array of disciplines and health professionals. In practical terms a clinical informatician should be able to lead an implementation of an Electronic Health Record (EHR). Sometimes this type of clinician is called a Chief Medical Information Officer (CMIO) although depending on the organization, a CMIO might have other responsibilities as well [38].

Table 4.1 summarizes the four main topic areas described by the CORE CONTENT team. Each of these topic areas had several sub-topics – in fact a total of 177 subtopics are outlined in the final document [36].

The Core Content team did not specify the relative importance for each of the main content areas but did elucidate subtopics, although the depth of details was not consistent. For instance, there were 32 subcategories for fundamentals and 69 for health information systems. Moreover, the level of specificity also varied. For instance, there were 30 subcategories of information systems with 10 related to data (not even including eight subcategories on data standards) while there were only five subcategories for effective communication. In total, the team identified 177 items in defining the core content. These different levels of detail presented some challenges for the test writing committee who needed to determine the weighting of the different content domains. Based on information provided by the American Board of Preventive Medicine's "Study Guide Materials Examination Content Outline" Website, the percentage of each of the four content areas is indicated in Table 4.1 [39].

Development of Clinical Training Program Criteria

The Clinical Training team consisted of primarily physicians, computer scientists and other professionals who had worked at establishing operational clinical systems and who had participated in clinical training programs. After completion of the

Table 4.1 Four topic areas describing the CORE CONTENT of clinical informatics [36]

Content [% of items on Board Exam]	Core content	Number of topics
1. Fundamentals [10 %]		**32**
Clinical informatics	1.1	13
Health systems	1.2	19
2. Clinical decision making and care process improvement [30 %]		**35**
Clinical decision support	2.1	23
Evidence-based patient care	2.2	8
Clinical workflow analysis	2.3	4
3. Health information systems [40 %]		**69**
Information technology systems	3.1	31
Human factors engineering	3.2	5
HIS applications	3.3	5
Clinical data standards	3.4	8
Information systems lifecycle	3.5	20
4. Leadership and management change [20 %]		**41**
Leadership models	4.1	8
Effective interdisciplinary teams	4.2	6
Effective communications	4.3	5
Project management	4.4	9
Strategic and financial planning	4.5	8
Change management	4.6	5
	Grand total	**177**

Core Content document, the Clinical Training team began its deliberations with Dr. Charles Safran, an internist and clinical informatician as Chair with Dr. M. Michael Shabot, a surgeon and clinical informatician as vice-Chair. The assignment of the second team of 12 experts was to determine how the "Core Content" of clinical informatics should be taught in a two-year fellowship training program [37, 40]. The team had to grapple with which of the 177 items of core content could be learned best by didactic instruction and which required experiential learning. Also the team realized that most of the existing training programs in biomedical informatics, which were designed to produce system developers and researchers, did not cover all of these content areas. The Clinical Training team concluded that each training program should be able to certify that a trained clinical informatician could demonstrate the competencies shown in Table 4.2.

To accomplish meeting the above noted goals the team determined that training programs should:

(a) Develop a curriculum with clear learning goals.
(b) Ensure fellow participation in scholarly activities that "advance fellows' knowledge of the basic principles of research, including how such research is conducted, evaluated, explained to patients, and applied to patient care."
(c) Provide didactic sessions to assure all "core content" is covered during a 2-year fellowship.

Table 4.2 Informatics competencies to be demonstrated at the end of training

1.	Search and appraise the literature relevant to clinical informatics;
2.	Demonstrate fundamental programming, database design, and user interface design skills;
3.	Develop and evaluate evidence-based clinical guidelines and represent them in an actionable way. All clinical informaticians should be able to represent such guidelines in a logical way, while others would be able to program them into computer code;
4.	Identify changes needed in organizational processes and clinician practices to optimize health system operational effectiveness;
5.	Analyze patient care workflow and processes to identify information system features that would support improved quality, efficiency, effectiveness, and safety of clinical services;
6.	Assess user needs for a clinical information or telecommunication system or application and produce a requirement specification document;
7.	Design or develop a clinical or telecommunication application or system;
8.	Evaluate vendor proposals from the perspectives of meeting clinical needs and the costs of the proposed information solutions;
9.	Develop an implementation plan that addresses the sociotechnical components of system adoption for a clinical or telecommunication system or application;
10.	Evaluate the impact of information system implementation and use on patient care and users;
11.	Develop, analyze, and report effectively (verbally and in writing) about key informatics processes.

(d) Provide "rotations [that] are experiential assignments, of finite duration … designed to provide fellows with exposure to different types of clinical and health information systems, in a range of settings that includes inpatient, ambulatory, and remote applications" [37]. These rotations should comprise 15 % of the two-year training experience.
(e) Provide a long term assignment for each fellow of at least 12 months on a project team.
(f) Fellows must conceive, develop, implement, and evaluate a substantive, applied Clinical Informatics project and present the results of the evaluation in a peer-reviewed setting.

In addition to public presentations of the two documents, more than 80 people participated in developing and reviewing the Core Content [36] and the Training Requirements for Fellowship Education in the Subspecialty of Clinical Informatics [37].

American Board of Medical Specialties Approval of Clinical Informatics as a Subspecialty

It was decided that clinical informatics was best pursued as a subspecialty. Clinical informatics cuts across many of the other medical specialties, and on a practical level, a subspecialty was more feasible to establish. Leaders of AMIA contacted member boards of ABMS to find which of the 24 Boards might be willing to take the lead in creating the new subspecialty of clinical informatics. The American Board of Preventive Medicine (ABPM) became the lead board and won approval for creating the subspecialty of clinical informatics. ABPM was then joined by the American Board of Pathology (ABP) to create the certifying process and examination for clinical informatics. All of the 24 member boards of ABMS allow their members to sit for the clinical informatics subspecialty examination, and it is likely in the future that many boards will adopt clinical informatics as a formal subspecialty within their specialty. The ABMS granted final approval of clinical informatics as a board-certified medical subspecialty in September 2011 [41].

The American Board of Preventive Medicine and the American Board of Pathology have become the primary sponsors of the subspecialty board certification. Physicians who are board certified in any of the 24 ABMS boards are eligible to become board certified in clinical informatics. All except those physicians who are board certified in pathology must apply for clinical informatics subspecialty certification through the American Board of Preventive Medicine. Those physicians board certified by the American Board of Pathology must apply through the American Board of Pathology [42].

To be eligible to take the first examination for board certification in the subspecialty of clinical informatics (October 7–18, 2013), the following requirements must be met [39]. Application completed from March 1 to June 1, 2013, AND

1. Have current certification by at least one of the member boards of ABMS; AND
2. Medical school or osteopathic school graduation; AND
3. Current license(s) in the USA or Canada; AND
4. Completion of one of the two Pathways noted below:
   (a) Practice Pathway – "Grandfather Path" – three years of practice in clinical informatics, significant clinical informatics responsibility, verified time of at least three years in clinical informatics for the five years prior to application, OR, for those who have completed a non-accredited fellowship training program of less than 24 months, curriculum and evidence of completion of the practice pathway are required
   (b) Fellowship Training Pathway – Completion of a fellowship program of at least 24 months in duration that is acceptable to the ABPM is required. Initially, a mix of Practice Pathway AND Fellowship Training Pathway will also be reviewed by ABPM. Starting in 2018, only programs that are accredited by the Accreditation Council for Graduate Medical Education (ACGME) will be eligible [40].

Developing the Board Certification Examination for the Clinical Informatics Subspecialty

The ABMS, in approving clinical informatics as a subspecialty, adopted the documents provided by the two teams [36, 37]. These documents are literally the foundation of the clinical informatics subspecialty. The ABPM and ABP, with guidance from AMIA, assembled an examination committee of 16 experts to develop a bank of over 300 questions for the online certification examination. The development of the examination for board certification adheres to the outline provided by the Core Content team, but since the core content team did not establish the level of importance of each of the content areas nor did they specify at what level of detail a clinical informatician should demonstrate their competency, these decisions were made by the examination committee.

From 2011 to 2013 the group of 16 experts met four times. Both Charles Safran, Chair of the Clinical Informatics Fellowship team and Reed M. Gardner, Chair of the Core Content team are members of the certification examination test development committee. The examination is a one-day, multiple choice question examination administered by Pearson VUE Professional Centers throughout the United States and at several international sites [39].

Because the actual examination questions and content are "confidential" for obvious reasons, only a broad overview of the methodology used is presented here. Standard test development procedures were followed. Questions writers with different areas of expertise prepared the initial questions and then each question was reviewed by the entire group of experts. Broad ground rules for developing the multiple-choice questions and answers were:

1. Questions should focus on the practice of clinical informatics, not the history of the field.
2. Questions should have one correct answer and about three distractors; True/False questions were not permitted.
3. Each question required an appropriate reference supporting the correct answer.

Because many members of the test committee were academic experts, the members are, of course, required to keep the test content confidential and cannot share the detailed content with their students, with their colleagues, and cannot "teach to the test" in their own programs.

The process of preparing questions and vetting each of them with the group of experts is complex and difficult. While the members of the Core Content team had a sense their work was historic, none of the team members understood how literally the core content outline would guide the construction of the Board Exam. For instance, we were quite detailed about "information systems" but less so about "clinical decision support." While clinical workflow was only briefly mentioned in the outline, that did not reflect its importance.

Moreover, important subjects like "workflow" or "governance" are barely mentioned in many of the classic or current textbooks on informatics. Most textbooks cover some, but not all of the needed content areas [20, 43–53]. The ABPM lists texts and journals that would be helpful for the examination, but these are likely to change over time, especially because the current texts do not cover all of the needed content. Certainly the academic and subspecialty field of clinical informatics is new and under development. As a consequence it should come as no surprise that few textbooks and formal training materials are currently available. In addition, as was mentioned earlier, many of the informatics training programs were designed to produce developers and researchers, not the applied clinical informatics practitioners for whom the certification is designed. Consequently, questions on content not covered in many current textbooks will be a challenge for physicians who want to use a textbook to study for the first examinations. New texts and training materials that are relevant to the new subspecialty clearly need to be developed. The American College of Pathologists has recently published a text *Pathology Informatics: Theory & Practice* which is broader than earlier texts in the field [51].

Accreditation of Training Programs in Clinical Informatics

Over the coming months and years, the American Board of Preventive Medicine will take on the responsibility for accrediting training programs in clinical informatics. Initial requirements for such accreditation were described by the Clinical Training team [37].

Clinical and academic programs at universities and healthcare organizations will need to organize and establish such training programs much as they have for Medicine and Surgery. However, it is likely that special efforts will need to be taken since several of the academic Biomedical Informatics education programs do not have close operational affiliations with clinical centers. While the AMIA 10×10 programs have functioned well for providing basic informatics education, clinical informatics requires that Fellows work in the clinical setting which is a much more challenging program to establish and run. Currently curricula for training in the field of Biomedical Informatics have a wide diversity of program content [54]. However, the content of clinical informatics fellowships has very specific and detailed requirements [37].

Challenges and Opportunities for Clinical Informatics

The next 5–10 years will present challenges and opportunities for clinical informaticians. Hopefully a large number of clinical informaticians who are “grandfathered” into exam eligibility will take the exam and become board certified. Such board certification will add credibility to the field and provide an excellent method for making the discipline of clinical informatics more professional. In addition, there will likely be new and innovative programs in clinical informatics that develop in the United States and Canada. The recognition of clinical informatics as a medical subspecialty with board certification will also have worldwide implications for healthcare education.

Since subspecialties in medicine no longer have “lifetime” tenure, those who are board certified in clinical informatics will be required to maintain their certification through a process of Maintenance of Certification (MOC). AMIA and other professional organizations will have the opportunity to offer courses and share successful clinical informatics experiences which will enhance the field.

Summary

While changes in healthcare delivery have made the need for clinical informatics specialists more obvious in today's world, the field has been evolving for over 50 years. Multiple experts in the field donated their time and effort to make the field of clinical informatics a reality. Those who donated their time, and those who will in the future, are what will make the field of clinical informatics a success and provide a significant impact on healthcare.

With greater maturity and visibility of the profession of clinical informatics, there has been a greater recognition of the need for specialty certification. Developing the clinical informatics subspecialty took hard work, excellent leadership and external funding. It was almost a decade since the initial efforts were initiated until the first certification examination was conducted. With nurses and physicians being able to be board certified, it is now essential that other healthcare informatics professionals have the opportunity to gain certification – computer scientists, computer engineers, pharmacists, and other medical technologists.

For the subspecialty to grow, hospitals and ambulatory sites must recognize the credentials reflected in the board certification, and must allow clinical informaticians to be involved and encourage them to participate in executive level activities – not keep them relegated to "off to the side geeks." This will be important for training programs as well. Strong training programs will be required to prepare physicians for the board examination and to certify the candidate's experience. Training of clinical informaticians will require both didactic learning that can be tested in a board examination and experiential training similar to all medical specialists. Although remote and web based training are becoming ubiquitous in medicine and other fields, clinical informatics will require a "live clinical laboratory". Training programs are developing and there will likely need to be accreditation of those training programs in the future.

Once the certification and accompanying training process becomes operational, it will be essential to evaluate the utility and effectiveness of board certification in clinical informatics. Clearly, there is still much work to be done. We have only begun on a long and changing journey to implement training programs, evaluate them, improve them and make continuous progress in the field of clinical informatics.

Lessons Learned

- External experts, who had gone through the process of getting board certification, were essential in developing clinical informatics board certification. As noted earlier, Dr. Benson S. Munger had recent experience with another Board at getting certification, and his help was invaluable.

- Obtaining professional consensus was essential and at times difficult. With highly competent individuals on both teams, there were several instances where strong feelings and values were held and these situations had to be resolved so that a workable consensus was reached.
- The initial documents guiding the Core Content and Training were a key reference for the examination committee and assumed more importance than the experts who created the documents realized.
- Because multiple choice tests are not routinely used in testing informatics trainees, there was a learning curve for the test committee to learn to write effective test questions for the examination.
- Many areas of expertise that clinical informaticians must acquire such as leadership and management skills are challenging to test in multiple choice formats.
- The process of Board Certification is a "living" process – which is continually changing and improving over time. Establishing "grandfathered rules" for the first board certification process was difficult and the rules may need revision over time. In addition, information that was essential 20 years ago may be obsolete today.
- Required interaction with other professional organizations was essential, productive and healthy.
- Because the competencies of the clinical informatician span academic and operational areas, there must be cooperation between several clinical, computer science, engineering, leadership training, business and management centers to provide optimal training and professional development.
- The recent Institute of Medicine Report about safe IT systems [55] provides support for the timeliness and importance of assessing the complex sociotechnical concepts that clinical informaticians will have to master.
- There are currently many texts about clinical informatics topics. However, none of them have been designed to fill the core requirements as outlined for the subspecialty of clinical informatics.
- The subspecialty of clinical informatics is a rapidly changing field as illustrated by the fact that the ABPM clinical informatics exam writing committee had to reject questions that were originally accepted during its first round of question preparation.

Key Take-Away Points

- Changes in the healthcare environment have created a need for clinical informaticians.
- Clinical informatics has been evolving as a discipline for over 50 years
- Subspecialty training and specialty board certification can add to the professionalism of the discipline.
- Creating an examination and training programs for an evolving field is challenging.

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Chapter 5
Education in Nursing Informatics

Jacqueline A. Moss and Beth L. Elias

Abstract Nurses at all levels of practice and specialization are, at their core, knowledge workers. They collect data from numerous human and electronic sources and organize these data for analysis and dissemination to all members of the healthcare team. Nurses and others use information derived from these data as the basis for optimum clinical decision-making. Increasingly, nurses are using technology to facilitate the collection and use of data and information in their practice and nursing educational programs are preparing them to gain related competencies. This chapter provides an overview of the use of technology in nursing practice and the computer competencies, information literacy, and data management content needed in educational programs to prepare nurses for basic, advanced, and informatics practice.

There are over 3.4 million licensed registered nurses residing within the United States making nurses the largest group of healthcare providers, exceeding the number of physicians by approximately five to one [1]. Over 60 % of nurses work in hospitals, however many are providing care to patients in other settings, including primary care, home care, community health, and long-term care facilities [2]. Nurses' work is as diverse and complex as the patients they serve. The one common thread in all nursing practice settings is the need for accessible, timely, and accurate information to inform decision-making and to ensure the provision of safe and effective care.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_5,

Using information to determine appropriate care has been key to the nursing profession from its very beginning. Florence Nightingale (1820–1910), who is credited with propelling the practice of nursing into the professional sphere, used data to provide information on the effect of nursing care on morbidity and mortality rates among soldiers during the Crimean War [3]. In addition to being a nurse, Nightingale was also a statistician, collecting and analyzing data to determine effective means for promoting sanitary and hygienic conditions that changed the structure and processes organizing hospital care. At the time of her death in 1910, she was a member of the United Kingdom's Royal Statistical Society and the United States' American Statistical Association. She recognized the vital importance of data to inform the practice of nursing and emphasized this as a foundational skill necessary for all nurses.

Today nurses follow Nightingale's lead as knowledge workers with their focus on clinical decision-making guided by data. Knowledge workers are those whose base for professional practice is primarily knowledge. This knowledge supports the high-level of problem solving that is required in their work. For nursing, this problem solving is highly complex because it must be individualized to each particular patient and circumstance. Information technology can provide the data needed to help meet this need and support positive patient outcomes and safety.

What separates the informatics content necessary for nursing practice from other types of professional healthcare practice is the role nurses play as members of the healthcare team. Nurses are at the information hub of the healthcare team in acute, home, and long-term settings. They collect vast amounts of data from patients, family members, other members of the healthcare team, and physiological monitoring and treatment devices such as cardiac monitors and insulin pumps. They then document these data, either on paper or electronically, and disseminate it to others either through the patient record, with communication technologies, or face-to-face.

In a study of narrative nursing documentation in an electronic record [4] nurses were shown to be using the narrative portion of the record to provide other team members with summaries of patient status and any unexpected events. This allowed other team members to quickly understand the patient status within context without having to assimilate this picture through a time-consuming review of the coded electronic portion of the record. Information communication technology is increasingly being employed to help accomplish this work and all nurses need to be comfortable with and competent in the use of these tools.

In this chapter, we will discuss informatics competencies and content in education as it applies to basic practitioners, advanced practitioners, and faculty in nursing. We will also describe the growing practice role of the informatics nurse specialist, those nurses who are prepared to support nursing practice through the application of nursing science, computer science, and information science to improve the health of populations, communities, families and individuals through information management and communication technologies [5]. This educational content is as dynamic as information technology itself today and will only continue to change and grow as information technology, the profession of nursing, and the healthcare environment evolves.

Health Information Technology Use

Growth in HIT use can be attributed, in part, to the Institute of Medicine's (IOM) Quality Chasm series of reports in which the IOM raised serious concerns about patient outcomes and safety [6–8]. In these reports the use of information technology is discussed as a means to improve patient safety while increasing efficiency. The IOM linked HIT and practice applications with an expectation that they will lead to improved data collection, data quality and therefore will allow for evidence-based practice, decision support and reduced waste, from, for example, repeat testing. Healthcare organizations are also expected to use regular analyses of these data to improve patient care, outcomes, regulatory compliance and reporting. Healthcare organizations and providers are also now being evaluated on quality measures that are tied to the use of information technology by both regulatory agencies and payors [9]. As we attempt to quantify measures around patient outcomes and safety, the higher level of data quality that can be achieved through the effective use of HIT is essential.

In addition to regulatory agencies and payors patients are also evaluating their healthcare providers. Patients increasingly expect their providers to communicate using information and communication technologies such as email, messaging services like twitter and through web browser-based patient portals. In the competition for healthcare dollars, having a comprehensive HIT infrastructure to support this expectation can give an organization the edge in attracting and keeping patients [10]. Professional groups such as the Healthcare Information Management Systems Society [11], American Hospital Association [12], and U.S. News & World Report [13] are adding to this pressure by publishing the results of surveys and rankings of healthcare organizations that focus on HIT completely or in part.

With the financial support provided in the American Recovery and Reinvestment Act of 2009 to increase the use of information technology in healthcare we have seen the number of Healthcare Information Technology (HIT) tools to provide information support at the point of care increase [14]. Organizations report that they plan on an increasing rate of HIT implementations even more in the future [15].

It is clear that nurses will be HIT users in their professional practice, making their education regarding the use of information and communication technologies even more important. At the bedside, devices that nurses have traditionally used in their work, such as patient monitors, intravenous pumps, and even hospital beds are being redesigned to integrate with data and communication systems to both collect and provide data at the point of care to improve patient safety. Increasingly, these technologies are being designed to be worn by patients in the outpatient setting both to collect data and to provide therapeutic interventions such as insulin pumps and implantable defibrillation devices. As more of us age-in-place in the future the number and sophistication of these devices will continue to grow. Nurses interact constantly with these integrated information systems, inputting and accessing data. In a study of nurses' information exchange in an intensive care unit, interaction with electronic sources was the second most frequent mode of information exchange exceeding all human interaction except information exchange with another nurse in the unit [16].

In all practice settings, nurses play an important role in the selection, customization, and implementation of HIT. They are essential members of inter-professional committees that work to customize interfaces, integrate workflow, train users, and develop policies and procedures related to the successful implementation and use of HIT. Because of their role as care coordinators, nurses are in a position to help decrease resistance and smooth the transition to new technologies and systems for other healthcare providers by providing just-in-time assistance at the point of care [17]. Adequately preparing nurses to knowledgably function in these roles will help ensure that these technologies are successfully implemented and applied to the practice setting.

Educational Mandate

According to the American Nurses Association, a competency is 'an expected level of performance that integrates knowledge, skills, abilities, and judgment' (p. 12) [18]. This definition clearly emphasizes the need to apply didactic content to achieve successful and effective performance in actual practice.

The effort to define nursing informatics competencies began in the 1970s to explicate the needed computer competencies for practice at the basic and advanced levels. The earliest competency recommendations tended to focus on the development of only computer skills such as typing [19, 20]. Over the years, it became apparent that nurses also needed to learn skills related to information literacy and information management to implement and evaluate patient response to evidence-based practice (EBP) interventions [21]. Over the last 10 years, defining informatics competencies for nurses across levels of practice and roles has been the subject of research studies. These studies have primarily employed survey design to collect data on needed competencies from those in nursing education and practice [5]. At this time, competencies have been identified for all levels of nursing education [22] and for various nursing roles [23].

Many organizations have called for the inclusion of nursing informatics content into nursing curriculum across all levels of nursing education and some have worked to provide guidance to educators on what competencies nurses need to practice safely in an increasingly technological environment. These organizations include: the National League for Nursing, Technology Informatics Guiding Educational Reform (TIGER) competency collaborative [24], and the American Association of Colleges of Nursing [25].

The primary organization responsible for guiding the development of nursing curriculum at all levels is the American Association of Colleges of Nursing (AACN). The AACN is a consortium of over 700 schools of nursing and works to define and guide the provision of quality nursing education. To support a consistent and effective curriculum, the AACN led a consensus-based effort to define competencies that are expected for both the pre-licensure and graduate levels. This effort resulted in the publication of the AACN Essentials Series. The AACN Essentials provides frameworks to guide curriculum development in undergraduate nursing education, master's education, and in the preparation of nurses earning a doctorate of nursing practice (DNP) degree [26–28]. Each of these Essentials documents includes specific guidance for the informatics competencies to be included at each level of education. The Essentials documents clearly indicate that informatics education is a required and integral component of nursing professional practice that must be woven throughout nursing education.

To ensure that the AACN Essentials documents are put into practice is the work of the Commission on Collegiate Nursing Education (CCNE) [29]. Working in partnership with the AACN, and using the Essentials documents as a guide, the Commission on Collegiate Nursing Education (CCNE) is responsible for reviewing nursing educational programs for accreditation. The CCNE is recognized by the United States Secretary of Education and works through a program of voluntary participation by Schools of Nursing. Certified Schools of Nursing programs for prelicensure and graduate levels agree to undergo regular review and thorough evaluation by the CCNE to ensure the highest level of quality and ongoing improvement. The CCNE pays particular attention to the bridging that must take place between the competencies learned at different levels of nursing education, with each level of competency building on the next throughout all levels of educational preparation. Poorly defined or ineffective competencies therefore will not allow for the continued building of informatics or other skills that are required as nurses continue their education or as they move out into practice.

While the AACN can be said to be the main guiding body when it comes to BSN education, the National Council for State Boards of Nursing (NCSBN) is making its own contribution. The NCSBN is a consortium of United States' Boards of Nursing and other national Boards of Nursing and is responsible for development of the National Council Licensure Examination for Registered Nurses (NCLEX-RN). State boards of nursing require passing the NCLEX-RN for the licensure of nurses for practice. The NCLEX-RN examination includes questions related to competencies in informatics outlined in the AACN BSN Essentials documents.

To further support BSN students as they complete their undergraduate education and move into practice, the NCSBN has developed *Transition to Practice*, a standardized transition to practice model with supporting tools [30]. As part of this effort, six learning modules were developed, one of whose focus is informatics. This module includes computer and information literacy competencies clearly identifying them as critical to a successful transition from the educational environment to practice.

Nursing Education

Because most Bachelors of Science in Nursing (BSN), Masters of Science in Nursing (MSN), and Doctorate of Nursing Practice (DNP) programs in the United States undergo accreditation from the AACN and use the AACN Essentials documents as a framework for curriculum design, the informatics competencies reflected in these documents are integrated into these programs. At all levels of nursing educational preparation, the informatics competencies outlined in the Essentials documents and tested for by state boards of nursing for licensure and certification are related to three areas: computer competency, information literacy, and information management.

Educating Nurses for Basic Practice

The AACN Essential IV for BSN students outlines the competencies that, according to the AACN, are requisite components of a BSN curriculum (p. 18) [26]. This Essential is titled *Information Management and Application of Patient Care Technology* and competencies specified in this Essential are primarily in the areas of: locating and evaluating literature regarding evidence-based practice; the use of information and communication technology; the use of patient care technology (i.e. smart pumps, bar code medication administration scanners), and the documentation, retrieval, and protection of patient data. For example, a BSN prepared nurse is expected to find and understand evidence-based practice guidelines and to be able to integrate them with their critical thinking skills to evaluate their patients' status. They must also be able to document this status in electronic medical records systems and to communicate in a clear and timely manner with other healthcare providers using a variety of voice and information system tools to coordinate patient care. Additionally, nurses must be able to use increasingly complex and informatics-enabled point-of-care devices to monitor their patients. Simply learning one system or one method for patient care is no longer an option. As information and communication patient care technologies evolve, professional nursing practice will increasingly depend on these competencies.

In addition to the regular classroom experience, clinical simulation is an effective method to provide experiential learning regarding technology use for the undergraduate student. The use of simulated electronic health records to document and retrieve both simulated and actual patient data has become very popular in schools of nursing, particularly in areas where the use of the actual hospital electronic health record is prohibited. Using a simulated record in a simulated patient experience with high-fidelity mannequins and patient care technology such as smart pumps, medication bar code scanners, and medication dispensing machines can provide the student with experience using these technologies in a real-world situation prior to encountering them in the practice setting.

For example, students who are immersed in simulation featuring a 'patient' who is experiencing chest pain, will need to skillfully interact with multiple technologies to care for this 'patient'. Initially, the student will be expected to assess the simulated patient and collect pertinent history and physiological information. This will involve the proper use of bedside medical devices routinely in use to provide continuous monitoring of blood pressure, pulse, temperature, and heart rhythm while simultaneously communicating and documenting these data into the electronic record. The student will then need to access past medical data in the electronic record, synthesize these data with current data being collected and communicate these findings to physicians and other healthcare providers. Increasingly, in the clinical setting, this is being accomplished not just through the use of the electronic record or telephone, but through the use of intrusive interruptive technologies such voice-over-Internet devices, communication tools and text messaging through smart phones. After the student has communicated patient findings to other providers, the student begins to provide care to the simulated patient, including administration of medication and drawing blood for laboratory analysis. Medication administration involves the use of multiple types of information and communication technologies that can be integrated into the student simulation. To administer medication to their simulated patient, the student must:

- Access and check the medication order in the electronic record
- Access and read information regarding administration of the medication, including: preparation of the medication, route and administration technique (i.e. intravenous push, drip, etc.), contraindications, drug-drug interactions, side effects
- Access and check any laboratory or physiological data that may be associated with administration of the drug (i.e. potassium level and blood pressure when administering Lasix)
- Access and check any other patient data that could impact administration, such as drug allergies, drug-drug interactions, or other patient contraindications (i.e. recent subdural hematoma and anticoagulants)
- Scan the simulated patient's armband and the drug bar-code
- Program the drug into a smart-pump intravenous administration device
- Monitor bedside device technology for the simulated patient's response to the drug administration.

While completing the patient simulation the student is required to document findings, medication administration, implemented therapies and interventions, monitor and react to laboratory and physiological data, all while interacting with patients, family members and other members of the healthcare team to coordinate the provision of care and to provide accurate information accurately and professionally. Familiarizing the student with these technologies through simulation can help decrease the chance for error when the students encounter these devices in actual practice and can increase their confidence in the clinical setting.

While the actual technologies can be very expensive for schools of nursing to purchase, a recent study has shown that there is little difference in the student's experience when interacting with an actual or simulated device. In a study comparing student performance and experience when taught to use intravenous smart-pumps using an actual pump and a simulated pump interface displayed on a tablet computer, researchers found little difference between the two devices [31].

Educating Nurses for Advanced Practice

Advanced practice nurses are educated at both the MSN and DNP level of education. The MSN advanced practice nurse is prepared to deliver high-level complex care to individuals and groups. Those advanced practice nurses prepared at the DNP level are prepared not only to provide individual and group level care, but to develop, implement, and evaluate system-level interventions that influence the quality of care provided to patient populations.

The AACN MSN and DNP Essentials documents provide guidance on what specific computer and informatics skills and knowledge advanced practice nurses require at each level. At the MSN level, Essential V, *Informatics and Healthcare Technologies*, emphasizes five broad areas of knowledge and skills that must be acquired: the use of technology to deliver and enhance care, the use of communication technology to integrate and coordinate care, data management and analysis to improve care outcomes, accessing and using health information for evidence-based care and health education, and facilitation and use of electronic health records (p. 21) [27]. At the MSN level a high degree of information literacy and information technology competence is required to support the role of the advanced practice nurse. As noted in the Essential, advanced practice nurses at the Master's level must not only understand how to use information technology tools for patient care as a BSN would, they must also be able to evaluate what information technologies are optimal for their practice and "the practice of others to enhance care outcomes" [27] (p. 18).

In addition nurses at this level must be prepared to use information technologies for the evaluation and analysis of patient data to improve patient outcomes, as well as for the education of other healthcare professionals and patients. The role of the MSN prepared advanced practice nurse expands beyond direct patient care to include practice guidance, policy promotion and design of education. The information technology competencies developed in the MSN Essentials lay a foundation to support these goals.

Essential IV, *Information Systems/Technology and Patient Care Technology for the Improvement and Transformation of Health Care*, is the DNP Essential that addresses the requirements for informatics and technology education at this level [28]. The competencies outlined in the DNP Essentials build on the MSN competencies and include additional competencies related to the collection, analysis and dissemination of data to improve care to populations; and the design, implementation, and evaluation of system level technological solutions. The DNP is a clinical practice doctorate that prepares the student for a level of practice that extends to the development of patient care interventions or standards of care at a population level. A DNP will use information technology, statistical analyses and the research literature to affect the care and improve outcomes for populations such as adult diabetics, breast cancer survivors, or for patients who present with symptoms of acute myocardial infarction at an emergency department.

Their focus on a population of patients requires that the competencies of an MSN prepared advanced practice nurse serve as the base for the acquisition of more complex information technology skills and knowledge. DNP prepared practitioners are expected to be in leadership roles, to be able to analyze and interpret the evidence-base, to apply this knowledge to improve patient care and quality measures, and disseminate this knowledge to others. This knowledge is informed by an understanding of the larger healthcare system, and the effect of information and patient care technology on that system. The informatics competencies at the DNP level reflect this intensely knowledge-based role and moves the DNP nurse beyond BSN level skill acquisition to support a patient care task, or MSN level guidance of practice, to a more in-depth level of understanding that includes the design of information technology tools, the evaluation of their capabilities, and the assessment of their impact.

At both the MSN and DNP level, the educational emphasis and experiences should be on acquiring the skills and knowledge to successfully apply the requisite competencies to practice. Too many educational programs confine their informatics content to an overview course on the use of informatics in healthcare without giving students the tools they need to competently work with technology in practice. Types of educational strategies that may be employed at the advance practice level are: the use and evaluation of online literature sources; the use of simulated and actual electronic health records; the modeling and design of databases; the use of software programs for data management and statistical analysis; and project design, management, and evaluation.

For example, assignments can be designed that teach students the basic elements of database models and design. The purpose of these assignments is to enable the advanced practice nurse to work with database and information system engineers, in the design of systems that collect and manage standardized patient data. The assignments also teach the student about the effect of different database models on their ability to analyze and track patient outcomes or use the data for developing evidence-based patient care protocols. In a two-part assignment we have developed at the MSN and DNP level, students are asked to demonstrate an understanding of the differences between the older flat file database model that has been dominant in healthcare information systems and a relational database model.

In the first part of the assignment, students are asked to convert a flat file structure provided to them into mock relational database tables. The exercise is done using a simple Microsoft Word document and asks the students, in part, to identify a primary key and foreign keys that link a parent table to several child tables. Data field types used in the table design should be appropriate to the type of data the field will contain. In the second half of the assignment, students use this mock design, and the feedback from faculty to build a small relational database using Microsoft Access.

The intent of this exercise is not to make them proficient in database design, although some choose to extend their education in this area, but for them to be fluent in the language of databases. They then can intelligently communicate with database designers and correctly communicate their field, table, form, and report needs. Students also gain an understanding of the limitations that some database models and designs can impose on the use of the data for analysis and data quality. The strategy of having hands-on experience with the tools, supports knowledge creation, builds confidence, and serves to bring together and solidify concepts presented not only in the informatics coursework, but also from other courses in the curriculum such as statistics. It can also serve to address one of the primary challenges we face, that of trying to break students out of the constraints of past experience with informatics, which has often been negative, so they can move beyond resistance and apprehension. Faculty being present as guides and information technology subject matter experts, as well as teachers through this experience is an essential supporting strategy for student success. This supporting strategy also models for the student, how to interact more successfully with information technology staff.

Advanced practice nurses, on graduation, are frequently involved with the evaluation and selection of bedside and system-wide technology solutions. An example of a skill-based project at the DNP program level we have used is the development of an informatics-based Request for Proposal (RFP). The Informatics RFP is a standard business process that identifies a need, assesses the need, defines technical and functional criteria for an informatics tool to address the need, defines evaluation criteria for potential solutions, and quantifies organizational resources required. In healthcare organizations RFPs are considered formal legal documents and are sent to potential vendors as the initiation of vendor selection and an informatics implementation process. The assignment is team-based and requires that students clearly and effectively communicate and work together to develop the RFP, as they will be expected to do in their practice.

By going through the RFP process, students gain working knowledge of the processes used to identify needs and to systematically approach the process of technology evaluation and selection. In addition, because the RFP is a formal business process, students are able to see the technology in the comprehensive context of the organization at the systems level. As with the database assignments, the RFP assignment can be challenging for students who may not immediately be comfortable thinking from an organizational perspective and who may not be familiar with the concept of an informatics application lifecycle. Strategies to mitigate these challenges are similar to those used for the database assignment. Faculty being present as a guide, teacher and consulting team member provides students with access to a subject matter expert, as they would have in the real world. This approach can also help support healthy team building and interactions by clearly, regularly voicing team goals and modeling positive team behavior.

Educating Informatics Nurse Specialists

As the use of technology in nursing care grew, so did the realization that nurses were needed who had specialized training to design, implement, and integrate these technologies into nursing practice. Although nurses have been working in this endeavor for over 50 years, the American Nurses Association (ANA) recognized Nursing Informatics as a nursing specialty in 1992. While Nursing Informatics has a great deal in common with the broader specialty of health informatics, the focus on data, information, knowledge, and wisdom in Nursing Informatics education is from the nursing perspective and relates to phenomena of interest for nursing [5] (p. 1).

The first specialty master's degree in Nursing Informatics was offered by the University of Maryland in 1989, followed by the first doctoral program in Nursing Informatics in 1992. Since this time the number and types of informatics specialty training programs in nursing has grown with the need for these nurses in practice and research. These programs offer a variety of educational options, including master's degrees, post-master's certificates, and doctoral degrees. Nurses prepared at the master's level in nursing informatics assume the title of Informatics Nursing Specialists (INS) [32]. Those holding a baccalaureate or master's in nursing with either extensive practice experience or informatics education can obtain board certification in nursing informatics, and the credential of Registered Nurse – Board Certified (RN-BC), from the American Nurses Credentialing Center (ANCC).

The American Nurses Association (2008) Nursing Informatics Scope and Standards of Practice provides: the attributes and definition of the specialty of nursing informatics, a guide for educators and those practicing nursing informatics, a reference for employers and regulatory agencies to define nursing informatics practice competencies and role responsibilities, and a source for information for others interacting with the profession legally and financially:

> Nursing informatics (NI) is a specialty that integrates nursing science, computer science and information science to manage and communicate data, information, knowledge, and wisdom in nursing practice. NI supports consumers, patients, nurses, and other providers in their decision-making in all roles and settings. This support is accomplished through the use of information structure, information processes, and information technology [5] (p. 65).

The first publication of the scope and standards document was published in1994; the current version is the fourth iteration of this guide.

The Nursing Informatics Scope and Standards of Practice describes the role of the Informatics Nurse Specialist within the context of the metastructures (Data, Information, Knowledge, Wisdom) (p. 3–7) [5] and the concepts and tools from information science and computer science (information technology, information structures, information management, and information communication) [5]. The Informatics Nurse Specialist functions in one or more of nine functional roles including: (1) Administration, leadership and management; (2) Analysis; (3) Compliance and integrity management; (4) Consultation; (5) Coordination, facilitation, and integration; (6) Development; (7) Educational and professional development; (8) Policy development and advocacy; and (9). Research and evaluation (p. 17–18) [5]. These functional units provide the framework for the development of educational programs in nursing informatics.

The MSN INS programs throughout the country generally have course work in three major areas: organizational and financial management, systems analysis and design, and project management. The organizational and financial management training provides the INS with an understanding of informatics from the business and enterprise perspective. This perspective gives them the skill set to ensure a good fit between the needs and constraints of the organization and information technology solutions. The systems analysis and design training prepares the INS with an in-depth understanding of all phases of the information technology lifecycle, from initial needs assessment through long-term use to final phase out. By including training in project management, the INS is given skills that enable them to successfully plan, execute and complete an informatics implementation or management project.

In addition, core courses specific to nursing MSN programs (i.e. evidence-based practice), and nursing informatics (i.e. nursing documentation and standardized terminologies) are included in their programs of study. Not all, but some, MSN INS programs also require a clinical component, where students are required to work in the practice setting with a preceptor who is working in the area of information systems analysis, customization/design, and implementation.

Informatics Nurse Specialists will play a key role in the healthcare team as agents of, and guides through, HIT change. Whether it is in the clinical setting, as an implementation consultant or in working for an HIT vendor these advanced practice nurses will help bridge the gap between the world of the healthcare practitioner and the information technologist. They will work to ensure that the voice of nursing is represented in all aspects of HIT from initial design to longitudinal evaluation in the clinical setting. As professional nurses they will also continue the tradition of patient advocacy, helping HIT developers and vendors remember those who are at the center of patient care.

Preparing Faculty

Schools of Nursing have had some success in implementing nursing informatics content into curricula across all levels of practice, however many have struggled to achieve this goal. The major barrier to integrating informatics competencies into nursing school curriculum is the lack of adequately prepared faculty to teach informatics content. The average age of doctorally-prepared nursing faculty is 53.5 years [33]. Very few nursing faculty were educated at a time when informatics content and competencies were included in the nursing curriculum. In addition, very few nursing faculty have any informatics background or education and few nurses prepared in informatics pursue an academic role. This leaves faculty without an understanding of key areas required to train students in informatics, such as the conceptual basis of informatics, systems analysis and design and the information technology lifecycle.

One solution is that faculty can prepare, at a basic level, to teach informatics competencies by completing certificate programs in nursing informatics or other course work such as that offered by the American Medical Informatics Association 10×10 program (See Chap. 8). Some master's prepared nursing faculty who are completing a DNP degree are choosing to complete additional course work in informatics to be prepared to teach basic informatics content to undergraduate and advanced practice nurses in clinical specialties.

Educational research and the development of innovative teaching methods for HIT learning are also needed. The focus of research and innovative teaching methods should include educating nursing students and their faculty. Not only students, but faculty in schools of nursing must also adapt and engage with HIT in order to successfully prepare professional nurses for practice. Faculty and students also must become and continue to be life-long informatics learners. It is the responsibility of educators, researchers and practitioners to keep current with the clinical environment that our students will ultimately be encountering and reflect that understanding in the student's training. Given the rapid rate of change and growth in informatics, this presents a challenge over and above those faced in preparing life-long learners in other disciplines. Life-long informatics learners must be comfortable with this rapid rate of change and flexible enough to adapt to new technologies as they emerge.

It is also critical that our research supports curriculum development and teaching methods that are evidence-based. As HIT changes, so must our educational efforts. Preparing faculty who are able to fulfill these responsibilities should be a primary focus of our work. This can be accomplished using a variety of methods from internal faculty development through mentoring and continuing education to attending professional conferences. The challenges faced include faculty workloads that are already heavy, making internal development particularly difficult. Professional meeting attendance is challenging in cost, both in dollars and time, and often is not at an appropriate level for those who are new to informatics. Both of these challenges may be lessened through the use of online, self-directed educational materials that allow interested faculty to develop an understanding of informatics and how they can integrate that into their coursework. Another means is to provide continuing education credits for informatics topics that can support faculty learning and professional license requirements.

Online Nursing Informatics Education

Many healthcare educational programs now include courses or parts of courses that are taught online. Online courses are particularly useful in graduate education where many students have work and family responsibilities that preclude them from attending face-to-face courses that are taught in a synchronous format. Online courses also allow students to further their education geographically distant from their homes at institutions with faculty knowledgeable in informatics without removing them from the patient populations that are so in need of their expertise. Three major challenges are associated with teaching nursing and other healthcare informatics content in a distant accessible format: development of faculty and technical resources to support online course development and delivery, developing experiential learning activities that can be delivered in an online format, and engaging students in meaningful team-based learning.

The use of online and blended courses in nursing education has a long history and most schools of nursing have courses that are delivered via distance and many have entire programs that are in an online or blended format. This is in part due to the efforts of the Health Resources and Services Administration's (HRSA) funding of distant accessible nursing programs to educate advanced practice nurses for populations in disadvantaged and rural areas. The intent of these programs is to increase the quality and access to healthcare in these populations without removing nurses from the populations they serve and may not go back to after moving to complete traditional live programs. Over the years, these grants have helped develop high quality, sustainable programs with a depth of faculty expertise in online delivery not often seen in other professional education disciplines.

The success of these programs has hinged on having adequate instructional technology resources. The necessity to devote adequate time and resources to a systematic faculty development program in online educational pedagogy cannot be overstated. Faculty are often apprehensive about teaching online initially, particularly if they have little experience using other educational technologies. Staff trained in instructional technology can smooth the way by preparing initial course shell structures, providing formal and just-in-time training, and providing individually-tailored support. Faculty need to be free to do what they do best; provide the best learning experience possible for their students.

Teaching students via distance can be a challenge in informatics courses where the acquisition of skills individually and working with a team are course objectives. Many software tutorials to develop database and other skills can be found online that can be accessed without charge to the student. In addition, instructors can develop step-by-step instructional modules through the use of learning object development software such as Adobe Captivate (http://www.adobe.com/products/captivate.edu.html). Developing effective student project teams online is a little more difficult. There are tools within online learning software that can support the formation of effective teams when combined with team building activities. Using a semi-structured team-building wiki teams can personalize the group space within the course, craft a mission statement, define team rules and roles, discuss previous team experiences and talk about what they wish to accomplish as a team participant. Adding a virtual classroom to the team's tools, with the ability to share documents, desktops and a whiteboard gives the students the ability to work together in a shared real-time virtual space. Chapters 2 and 11 provide additional suggestions for online education.

Finally, communication both between faculty and students and between students is crucial to a successful online course. Communication modes include: email, discussion boards, blogs, wikis, synchronous webinars, discussion rooms, telephone, and face-to-face. Expert faculty use most of these communication modes in the same course, matching the communication mode selection with both the type of communication and the preferred mode of student communication. It may be even more important in an online course than in a face-to–face course that faculty are excellent communicators, respond to students quickly and clearly. As in any class, being responsive to students and their needs communicates to students that you care as an instructor and that their learning and success is important to you.

Summary

Healthcare Information Technology is dynamic and rapidly changing. As HIT and its use mature nurses will be challenged to adapt and engage with what can be described as a moving target. The importance of educating nurses not only in the use of HIT, but in becoming life-long informatics learners cannot be overstated. Patient care, quality measures and job satisfaction will all depend to a significant degree on the ability of the nursing workforce not only to grow with HIT but to play a role in guiding that growth.

From the clinical practice-based competencies of the Bachelor's prepared professional nurse, the systems and information technology-based competencies of the INS, the leadership and population health-based competencies of the Doctorate of Nursing Practice and knowledge creation-based competencies of the Doctor of Philosophy in Nursing, understanding informatics is essential to all aspects of becoming and practicing as a nurse, teaching as a nursing school faculty member and in conducting nursing research. Nursing is a practice profession and at each level of nursing education, educational emphasis in informatics should be on equipping nurses to apply informatics competencies in practice to enhance the care and health of individuals. As informatics educators at all levels we face an exciting future rich with potential to advance the practice of nursing with the help of informatics and information technology.

Key Take-Away Points

- Computer competency, information literacy, and information management are key competencies for successful nursing practice. These are the basic competencies needed by both faculty and students and courses that only provide an overview of informatics as a field are not sufficient to meet this need.
- Students are more easily able to transfer content to the clinical setting when the educational experience most closely mirrors what they will encounter in practice; simulation is an effective strategy to achieving fidelity for optimum transference.
- Instructional designers to support faculty in developing and delivering distance-accessible courses enhance course quality and the educational experience for both faculty and students.
- Successful online instructors maintain near-constant contact with their students through multiple modes of communication. Well-designed courses engage students through varied and interactive content.

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Chapter 6
Applied Informatics for Health IT Managers

Amanda D. Dorsey and Meg N. Bruck

Abstract The Health Informatics program at UAB, an early exemplar of an applied health informatics program with a focus on health IT managers, has been able to address the changing needs or the seeming "moving target" of requisite skills needed in the healthcare IT industry. In this chapter, we examine some of the key factors and influences that led to the increasing importance of information technology in healthcare and the concomitant need for individuals with a background in health informatics to oversee the use of those systems. We discuss the development of the health informatics program at UAB, the path our own program has taken over the years and some "lessons learned" along the way.

Informatics education is often misunderstood. Like the discipline itself, which can cover areas as diverse as nursing, physicians, information retrieval, computer programming and others, the educational career paths of graduates of these programs can be varied and there is no "one size fits all" approach to delivering formal academic programs in health informatics. Assumptions about what health informatics graduates can or should be able to "do" once they're graduated also vary widely. As educators and as directors of informatics programs, this makes management of our stakeholders' (i.e. future or prospective employers, hospitals, vendors, etc.) expectations somewhat challenging. This variability has also allowed for a degree of flexibility in areas such as curriculum development, professional development and relationship building with external partners. The health informatics program at UAB, an early exemplar of an applied health informatics program with a focus on health IT managers, has been able to address the changing needs or the seeming "moving target" of requisite skills needed in the healthcare IT industry. In this chapter, we examine some of the key factors and influences that led to the increasing

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_6,

importance of information technology in healthcare and the concomitant need for individuals with a background in health informatics to oversee the use of those systems, the development of the health informatics program at UAB, the path our own program has taken over the years and some "lessons learned" along the way.

A Brief History Lesson

A series of legislative actions that occurred over the early to mid-60s helped form the need for informatics as a discipline in the United States. Perhaps the most important of these was the signing of the Title XVIII and XIX amendments to the Social Security Act in 1965 by President Lyndon B. Johnson, which laid new ground for the way healthcare is delivered, reimbursed and accessed [1]. Medicare and Medicaid, established by this act, gave millions of people access to healthcare services they had previously never experienced. This access led to not only increased use of healthcare facilities, it also increased production of health information that would need to be carefully and systematically managed and coordinated. At the time of this law's passing, this management was done primarily by non-clinical staff, and was entirely a paper-driven process.

In the same decade, the "great space race" fueled increased funding for science education and technology spending. While most of this was relegated to the business world, new billing computer systems were implemented in many hospitals, introducing most to their first encounters with automated processing of information. Continuation of the Hill-Burton Act in the 1970s, which gave funding for hospitals to expand their facilities, led to increased hospital construction. Hospitals had to get bigger in order to accommodate the influx of patients who now had assurances of receiving healthcare through Medicare or Medicaid. The capacity for hospitals to submit bills for the services they provided only increased. At the vortex of all three expansions (increased access to healthcare, hospital growth and increase in bill submission), was the proliferation of vast amounts of information about an expanding population of patients. But who would manage all that information? Who had access to it? What could be done with it?

Throughout the 70s and 80s, we saw an expansion of technology beyond the mainframe billing systems and the benefits of computing power was no longer limited to those "behind the scenes" and with very special computer science training. To meet the demands of the increase from federal and state reporting agencies about care provision, some of the clinical disciplines like laboratory, radiology and pharmacy began to see the use of automated systems. Large amounts of information were beginning to be readily available to members of the administrative and clinical communities within hospital settings. But the question remained, who was managing all that information? Who had access to it? What could be done with it? Clearly, the idea that there was a need for individuals with could manage people, vast amounts of information and analyze and design technology was beginning to emerge.

Formation of a Graduate Program in Health Informatics

During the 1980s, the National Library of Medicine began awarding grants to U.S. educational institutions for the purposes of funding graduate education and research in many areas of healthcare and biomedical informatics. The NLM program allowed these institutions to recruit trainees, who would then go on to study and conduct research centered on healthcare, computers and communications technology. The primary focus of these programs was on the medical side of information technology and research. These programs served as precursors to many other healthcare-focused computer science and informatics programs beginning to emerge around the country.

With the advent of many new technologies in healthcare settings and increasing demands to show productivity and efficiencies, many hospitals sought to expand responsibilities for their IT beyond the duties of a data processing manager and hired a Chief Information Officer (CIO). While the CIO's job was more strategic in nature, that is to manage information on a larger scale and to keep up with the proliferation of technology, the healthcare industry did not have individuals with formal training in this area. Data Processing Managers typically had a strong command of the technical environment, but were weaker in the areas of understanding the business of healthcare, the analysis and design of systems and lacked an understanding of the information needs of the clinical communities that they served. The need for this type of individual, and its lack in most healthcare settings, was one of the driving forces in the development of a graduate program that would train individuals to fulfill the skill set required of healthcare CIOs.

In 1989, in the Department of Health Services Administration in the School of Health Professions at UAB, a proposal for a graduate program that prepares senior level managers in the areas of strategy, management and implementation of technology in a healthcare setting was introduced. With the growing introduction of clinical IT systems into healthcare, these goals of the proposed program were aligned with the same goals that were being articulated for the Health Information Management (HIM) profession. The American Health Information Management Association (AHIMA) maintained that the traditional roles that HIM professionals had filled in traditional Medical Records departments were expanding beyond management of the paper medical record, which had long been the central focus of work for many in the HIM profession [2]. The program goals were also aligned with some of the medical informatics training programs, which were beginning to focus on the development of applications that could be used in actual clinical care.

Because of compatibility with the goals for the future of HIM and because UAB had an HIM undergraduate program, the original title of the degree was a Master of Science in Health Information Management (MSHIM). At the time, AHIMA, the professional organization for the HIM profession, was focused on bringing individuals with associate-level training in HIM up to the baccalaureate or four-year degree level. While individuals with an associate degree and the Registered Health Information Technician (RHIT) credential were employed, HIM professionals would need more academic preparation to assume the leadership roles of the future, and this would be done primarily by moving minimum education standards to the four-year degree level. A masters program was a step ahead of where most HIM programs were focusing.

The curriculum for the proposed program centered on five major components:

1. Foundations
2. Research methodology
3. A thesis project or
4. Administrative internship
5. Electives

According to the original proposal, approved by the University of Alabama Board of Trustees, the objectives of the program were the following:

1. Promote quality of care and cost containment in healthcare facilities.
2. Integrate knowledge of the health services environment and health information with skills in management of health services and health information.
3. Facilitate coordination of clinical, administrative and financial information into interactive databases to better support strategic planning and decision-making in the new healthcare environment.
4. Prepare individuals to assume positions as health information managers or chief information officers.
5. Provide an academic framework to prepare existing healthcare professionals for upward mobility into emerging managerial roles.

Formation of the MS-HIM Program Curriculum

While the focus of the program was to prepare individuals academically for their future careers, it needed to be firmly rooted in the required skill sets of current healthcare CIOs. The director of the program recognized that in addition to the current faculties' efforts, input into the program's curriculum needed to involve individuals currently serving in this capacity. An Advisory Board comprised of individuals from professional organizations, IT leaders in other academic medical centers, professional services consulting firms, and vendor organizations was formed and contributed to the program's curriculum and long-term planning needs.

The original curriculum was based on an empirical role delineation study of hospital CIOs, and the coursework centered around tasks commonly performed by those in this role [3]. In the survey, over 200 CIOs were asked about the tasks most commonly performed and the relative importance of each. The result was a categorization of skills that any healthcare CIO would need in order to be effective. From the study, the emerging idea was that while we had devised an advanced degree in HIM, most HIM professionals were not assuming CIO roles yet. The faculty felt strongly that moving toward a more applied focus in applied informatics, rather than

HIM, would give the degree more value in the healthcare industry. As the 1990s unfolded, AHIMA refocused its professional and academic emphasis on the management of electronic health records (EHR), which created a stronger linkage between applied informatics and health information management. But the relationship with AHIMA and another organization, the American Medical Informatics Association (AMIA), would yield considerable collaborative opportunities to promote informatics education. This relationship is elaborated later in this chapter.

Original Curriculum

The set of courses based on the CIO roles and functions included a set of core foundational courses that all students took as well as research methods and statistics. In addition, students were allowed several electives. The courses in the original curriculum are listed below.

Foundations

- Clinical Documentation and Information Systems in Support of Patient Care
- Healthcare Facility Data Communications
- Healthcare Information Resources Management
- Administrative and Financial Information Systems
- Quality Management in Information Systems
- Negotiating Contracts for Healthcare Information Systems
- Strategic Planning and Benefits Realization for Healthcare Information Systems
- Seminar: Synthesis of Health Information Management
- Information Systems and Management Science in Health Services Administration
  - Systems Analysis
  - Database Management
- Healthcare Delivery and Management Science
  - Introduction to the Healthcare System
  - Organizational Theory and Behavior
  - Financial Management
  - Management Science or Healthcare Elective

Research Methods and Statistics

- Courses in quantitative and qualitative methods and scientific inquiry

Electives

- Courses in topics related to information management, computer science, management, and specific to student goals and specialization

Thesis/Project or Administrative Internship

Because many students have professional and personal obligations that cannot be overlooked, two options for completing the degree were designed. For the non-traditional student who works full time or has other responsibilities, the Non-Thesis Research Project was recommended. The project option does not require a formal thesis, but a minimum of 30 semester hours of appropriate graduate work must be completed in good academic standing prior to beginning. Although thesis research is not required, the student is expected to gain insight into the techniques of informatics-specific problem posing and problem solving; using these insights to prepare a written report and a presentation on their findings to faculty members, fellow students, and their project mentor(s).

For traditional (younger or non-working) students, the Administrative Internship option provides an immersion experience by which they may gain more informatics-specific experience. The administrative internship option provides an opportunity for focused investigation of informatics problems in real-world settings and for application of problem-solving methodologies for development and execution of solutions. Investigation and application of theory is done through a practical implementation project.

> **Lesson Learned**: *By basing the curriculum on the skill set of the role we were training for and by using empirical data to help define that skill set, our students were able to function well in the newly emerging role of managing the enterprise IT systems.*

Changing Landscape of The University of Alabama at Birmingham and an Increase in Health Informatics Master's Degree Offerings

During the early 2000s, The University of Alabama system (including UAB) made a requirement that all of its campuses would begin operating under the semester system, rather than a mix of quarter-term and semesters. While initially the new academic structure required a challenging revision of the entire curriculum to meet a new timeline, it also provided an opportunity to eliminate some courses that were less central to the current needs of the healthcare IT industry. This change actually allowed the program to be competitive with the number of health informatics master's degrees and concentrations beginning to emerge across universities in the U.S.

The curriculum, while robust and unique in its offering, was extensive and time-consuming. At 63 credit hours, it was nearly the same length as the coursework for many PhD programs. To maintain viability and competitiveness, it needed to continue to be culled, yet still include the required competencies for the emerging healthcare IT management market. Stripping it of many electives and combining course content, where appropriate, allowed the program to remain an attractive offering in the academic marketplace. As discussed later in this chapter, as online education programs became more feasible and as more students expressed interest, this mode of education was revisited and the curriculum was modified into an online format.

Lesson Learned: *The changing educational landscape combined with the needs of students and demands of the field should promote a continual reassessment of coursework and requirements.*

Recruitment and Retention

The MSHIM program was designed to attract individuals with varying backgrounds of professional and academic training. Because of the strategic needs of the CIO, those with management experience were preferred, since they could more easily move into a senior leadership position upon graduation. The first students entered the program in spring of 1991 and had work experience that varied from 5 to 15 years across a variety of positions. Students were primarily located in Birmingham, and many of them lived very close to the UAB campus because of their employment by the University of Alabama hospital, the academic teaching hospital for the University of Alabama School of Medicine, which offered tuition benefits.

Some students were full-time students completing their degree in a little over 2 years. Others, however, worked full time and took classes part time. The added flexibility of being able to enroll in any of the three terms per year was a bonus for working professionals who wanted to expand their career options. Likewise the administration of the program realized that, unlike full-time students, part-time graduate students who were working professionals have shifting priorities in their personal and professional lives that often put school on the back burner. The program allowed students to "drop out" of courses during or before one term and pick the courses back up the next time the course was offered. It was not uncommon to see students take classes for only two of the three traditional terms (fall, winter/spring, summer) because the course offerings were not always aligned with students' schedules.

Changing Student Body and Healthcare Environment

Over time, the student body became more diverse in both profession and degree of experience. Some of the students continued to be those with a great deal of experience in the field of health information technology, while others were clinicians with limited technical knowledge, who were interested in getting into the Health IT field. Still others came with a strong technical or business background, but with very limited knowledge of healthcare. Finally, many applicants were foreign students with technical and clinical expertise, but no knowledge of the U.S. healthcare system. While this diversity was in many ways stimulating, it was also very challenging to bring the students to a basic level of expertise in healthcare and technology. Clinicians needed to become more comfortable with the technology, non-clinicians needed to know more about healthcare, and both groups often needed to become more knowledgeable in management and health informatics theory and concepts.

By the late 1990s, Internet usage had become routine. Home users were connecting with faster modems, or buying services from their phone or cable companies for high speed Internet access. Businesses that were using e-mail for internal and external communication began taking advantage of the growing network of home users. Newspapers and magazines offered content on the World Wide Web, libraries placed their catalogs and vast archives on the Internet (FTP or Telnet really), corporations set up informational and advertising websites.

Healthcare was no exception. Hospital administration and finance departments needed to connect with the Internet to carry out normal business. Large data sets which used to be transmitted on magnetic tape were able to be sent instantaneously via FTP. Large financial transactions were conducted electronically.

But the infusion of the Internet was not limited to the back-office operations of healthcare. WebMD, which launched in 1996, provided medical information to the average Internet user. Connected patients could look up their symptoms, research their diagnoses, and access information which was previously unavailable to them. Clinicians also benefitted from the Internet. Large reference volumes first became available electronically, such as the Physician's Desk Reference, and later were available via the Web.

Technology was changing rapidly to keep up with the growing demands of the Internet. Physical networks were carrying more bandwidth. Phone companies were investing in fiber optic cabling to support the aspirational gigabit Ethernet. Wireless networks were growing in popularity as the protocols supported more bandwidth and encryption became stronger. No longer could the healthcare IT executive delegate the responsibility for infrastructure to the IT Operations Manager.

A decision was made to revamp the Networking and Communications course to provide more of a foundational knowledge of the concepts. The course contained a lab component in which students had the opportunity to install and configure their own networks, experiment with public key infrastructure and certificates. To further expand the scope of technology in the program, the software design and analysis courses were modified to focus more on computer programming.

While the NLM training programs (see Chap. 3) focused on developing informatics applications and hence, incorporated significant computer programming experience, the UAB program was aimed at preparing system managers and had not previously had as strong to much of a computer science and engineering focus. The change, coupled with the varied student backgrounds, was challenging for both the students and the faculty. In the networking course, the students gained a very thorough understanding of the technical details of the infrastructure. However, while this was helpful to the students who had some background in IT, or for those students who were just more technologically inclined, those students with a healthcare background, who understood the importance of using technology, failed to see how understanding the distinction between hub, routers and switches was relevant to their needs.

Because so many of the students had no prior experience with programming, the majority of time was used to help students understand the different types of variables, when and how to use functions, and the advantages and disadvantages of stored procedures. Students at all ends of the spectrum found this approach to be unsatisfying. Those with more technological background found it too basic and those without the background could not see the relevance to the big picture of managing the technology.

The IT manager today is expected to be the bridge between the clinicians, the administrators and the technical staff. The negative student reaction prompted a reevaluation of the level of proficiency required for key the target role. To train the executive, the curriculum needed to address a variety of programming languages to highlight the different uses for each. More time was needed to emphasize the importance of the design process, how to gather requirements, elicit feedback, and do proper quality assurance. Today, the curriculum is more technical than it was when the program first started, but is less focused on the technology per se and more on how it is used than it was in the interim period.

Lesson Learned: *Comfort with, and knowledge of, technology is essential for anyone choosing health informatics or health IT as a career. Because teachers in health informatics tend to be technically proficient themselves, there is a risk that they will misjudge the needs of students who are not going to be application developers or informatics researchers. The degree of proficiency and the depth of knowledge of various subjects must be geared to the requirements of the role to which the educational program is aimed.*

Changing Learning Environment

It became clear that much of the flexibility offered by the program came at a cost. Students often lacked continuity with one another during their matriculation, which is an important element in the long term success/satisfaction with graduate programs. Students often commented about the lack of unity among their fellow students, who they would see in class for a few semesters, but then might not see again for another year. If the program desired graduate students who would be invested in their education beyond graduation, it needed to provide a more cohesive delivery format and give the students more of a sense of community and belonging. Likewise while the curriculum was very attractive to working professionals, the market of qualified individuals in the Birmingham area was eventually saturated, and the target audience beyond Birmingham was being paid too well in their current jobs and was not interested in moving somewhere else to complete a degree.

To align students' expectations and reduce the administrative time spent managing matriculation plans of individual students, the decision was made to decrease some of the curricular flexibility and move to a cohort model, admitting students as a "class" only in the fall semester. While the initial change meant a drop in admission of students, there has been an increase in camaraderie, networking and sense of identity among the students. In order to capture the growing market of students who were interested in health informatics degrees, the decision was made to offer courses in a blended-delivery format of two brief on-campus visits per year with most of the course work delivered in an online format. Even when the overall content was similar to the previous courses, the decision to move to an asynchronous distance learning format required a redesign of the specific content and especially the pedagogical methods as well (see Chap. 2 for more discussion of online education).

UAB was an early adopter of online informatics education, but the decision was guided by the same environmental assessment that had guided previous curricular changes. Today, in the U.S. and elsewhere there is an increasing number of online informatics education offerings, as shown in many of the other chapters in this book.

Health Informatics Managers of the Future

Role of Professional Associations

Throughout the course of our program's existence, various members of the faculty have held leadership positions in national, state and local chapters of the Health Information and Management Systems Society (HIMSS), the American Medical Informatics Association (AMIA) and the American Health Information Management Association (AHIMA). Membership and visibility within each of these professional organizations has merit and these organizations' goals of promoting better healthcare through the effective use of healthcare information and technology align with the program's goals. However, since each organization has somewhat differing interests, it can be challenging for a program such as UAB's, with students from varying backgrounds, to determine which organization best matches its current, and more importantly, future directions. Similarly, it can be challenging for students to select programs that are most closely aligned with their background and interests. In an attempt to sort out the differences among the organizations, AMIA and AHIMA have stated that "AMIA is the professional home for informatics professionals who are concerned with basic research in the field or any of the biomedical or health application domains, either as researchers or practitioners. AHIMA is the professional home for health information management professionals, with a focus on those elements of informatics that fall under the health informatics area of applied research and practice" [4]. Still, this distinction is not entirely clear to outsiders. Each of the organizations also has recommended competencies for students and requirements for informatics educational programs that are similar but not identical. AHIMA has a long history of certification examinations for individuals [5] and most HIM programs are accredited by The Commission for Accreditation of Health Informatics and Information Management Education (CAHIIM) [6]. HIMSS has developed a number of individual certification programs including the Certified Professional in Health Information & Management Systems (CPHIMS) and a new certification program for entry level professionals, Certified Associate in Health Information & Management Systems (CAHIMS) [7].

In late spring of 2007, AMIA gained funding from the Robert Wood Johnson Foundation to define the content and training requirements for a medical subspecialty in clinical informatics. Ultimately, the American Boards of Preventive Medicine and Pathology became the sponsors of the new subspecialty examination, with the first certification exam in the fall of 2013 (see Chap. 4 for additional details). While the medical subspecialty has not had a significant impact on our curriculum or our target audience, it has heightened the awareness of the formal role of informatics in the clinical community. Likewise, the curriculum requirements for this subspecialty align very nicely with our program's existing curriculum. Clinical informatics, which had once been a profession often described as "doctors who like computers" now had a legitimate home and a recognized credential, which serves to standardize the training that clinical informaticians receive and ultimately, may expand training opportunities [8]. In addition, an AMIA task force has published a definition of competencies in biomedical informatics that go beyond those for the physician subspecialty in clinical informatics [9]. Maintaining visibility in all three professional organizations is crucial to our program's success. Our faculty's long-term commitment to each organization has resulted in invitations to participate in their long-range academic strategic planning efforts, where we've been able to provide perspective and recommendations that will affect future informatics and health information management graduates and faculty.

The curriculum will be guided by all three of these professional organizations, to some extent, for the foreseeable future. From a marketing perspective, it will be important to outline, for future students and faculty, the parallels between the organizations and how we work with them. Examples may include a crosswalk between the three professional organizations' academic preparation goals (i.e. content areas) and the resulting target career paths of each group.

Lessons Learned:

1. *The professional informatics associations are a useful source of information for educational programs for guidance in defining the competencies their graduates need.*
2. *Informatics educators should stay involved with the informatics professional organizations to learn from fellow educators and to shape the organizations' directions.*
3. *Unless one organization is completely aligned with program goals, it may be advantageous to maintain affiliations with multiple professional organizations.*

Managing the Challenges of the Future: Politics, Shifts in Informatics Foci, and Emerging Technologies

The Political Landscape

The health IT political environment over the last 20 years has been in a constant state of flux and it was often a challenge to keep the curriculum current. For instance, although the Health Insurance Portability and Accountability Act (HIPAA) [10] was enacted in 1996, the initial standards for privacy and security of protected health information were not finalized until 2003. During this time, there was a great deal of confusion about the exact requirements of the law and when the standard would take effect as there were numerous extensions and waivers and exemptions. Since privacy and security were a key part of the curriculum, these changes needed to be incorporated.

The HIPAA law and the privacy and security regulations took a prominent place in the curriculum (and in every doctor's office). This was a new and evolving topic and the instructors were constantly adapting and updating their materials. In many cases, they were reviewing the new rules alongside their students – many of whom were working and implementing the policies in local healthcare organizations.

Another major impact was the passing of the HITECH Act, part of the American Recovery and Reinvestment Act (ARRA) in 2009 [11], which brought a major up shift in adoption of health IT. Our existing program's curriculum has prepared many successful individuals throughout its history, but with this passage, we now face near constant change in the knowledge base and required skill sets for healthcare IT professionals. These changes will certainly have an impact on our future curriculum and the ways in which it will need to be offered. For example, since the program's inception, we have focused on training individuals to assume leadership positions primarily in managing healthcare information technology primarily in hospitals. While this continues to absorb many healthcare IT resources, the adoption of healthcare IT in the outpatient environment has grown significantly. With this shift comes the need to concentrate more critically on the goals, management, workflow and motivations of individuals working in outpatient physician practices – both small and large, primary care and specialty clinics. The type of technology that is implemented in practices can be quite different and there are now many delivery models (cloud-based vs. in-house, independent vs. hospital owned) and adoption strategies that must be considered. One of the main strengths of the graduates has been their ability to convince healthcare organizations' leadership of the advantages of moving toward an electronic health record. The passage of ARRA made this particular purpose somewhat obsolete, since now it does not take much convincing. In a sense we reached and crossed the finish line but a sizable portion of the curriculum was still centered on strategies to convince people they needed to make the leap to an EHR; and the ensuing system selection and implementation strategies. It is important to shift our focus to look at the skill sets of leadership in a world where the use of health IT is accepted as part of the cost of doing business.

As has been stated elsewhere, graduates' primary role was to both influence, and support the clinical, administrative and technical communities of practice and we have achieved success in these areas. But we also recognize that we are training a workforce that has always had technology at their fingertips and expects it to be a constant support to them. In other words, these "digital natives" do not need to be convinced of the merits of using technology; they sometimes do not know how to manage without it. This shift is also becoming evident in patient communities becoming much more knowledgeable about technology. With technology to manage nearly every aspect of their lives, patients now expect healthcare to keep up at the same pace and support them in their health management goals. The rise of the patient as a consumer will require a shift in the focus of our curriculum from its original target audience (i.e. those working or practicing in healthcare organizations, where their primary clientele were administrators and clinicians) to individuals who have a greater understanding of the information technology needs of patients. Understanding the motivations and needs of the patient community will require knowledge of new strategies to elicit information and new ways of forming relationships beyond those required for interaction with clinicians and administrators.

The passage of the ARRA HITECH Act actually allowed us to look beyond EHR implementations and restructure our curriculum in ways that will be beneficial for students for many years to come by focusing on optimizing existing systems to enable better patient care, increase engagement and satisfaction, provide a more satisfying user experience and help organizations think of data from the EHR not just as canned reports, but as an organizational asset, that, with proper analysis, can be used for healthcare quality improvement and increased efficiency. However, the increased focus on the patient and the need for academia/practitioner collaboration is not the only change on the horizon. Increasingly the use of social media is a part of patients' lives and will need to be incorporated into healthcare IT as well. Managing healthcare IT in the future will require integrating genomic data with clinical data as personalized medicine approaches begin to be incorporated in healthcare. All of these rapid advances in technology and changing roles of health IT leaders will require individuals who can balance the risks and rewards of innovation as the scope for health IT leadership and management expands.

Successful planning for, and management of, the constant changes in healthcare IT require the full-time attention of interdisciplinary teams. This can be modeled in the educational setting by involving adjunct faculty from the practitioner community with the design and implementation of our courses and opens up more opportunities for collaboration between academia and practice.

Summary

The educational path that has been forged for future informatics managers has been an interesting and rewarding one. Informaticians, once a voice in the wilderness for promotion of information and communication technologies to improve healthcare outcomes, have begun to see support from professional associations, academia, and more recently, even from public citizens. The joining of these voices has mostly been harmonious, and the traction that has been gained has led to an increasingly higher focus on the necessity of formal informatics education and training. But the present rate of change in both our technical and political realms will ultimately determine our future. Issues such as the fate of Obamacare and other pending legislation, the ability to bridge the "digital divide" (i.e. those who should, but do not have access to technology that could help them) and the ability to keep up with the unprecedented era of "big data" need to be very carefully considered and integrated into the curriculum. This is not to say that our curricula and programs should or will be a driven by the most recent trends, it merely means that we are dealing with a rate of change and support that has never been seen before. The ability to impart and balance the enduring curricular components that are the foundation of many of programs with the rapid rate of change in the healthcare IT industry will present many new challenges to program directors. Likewise, we are beginning to see interest in informatics education from the "digital natives", or a student population that does not know or understand a world without technology to support it. Teaching this new population of students will require a shift from our traditional means of delivering education to thinking about student learning in ways that we have not done before. There is no shortage of management challenges facing us, and our future as program directors, faculty, advisors and mentors seems tenable for the foreseeable future.

Key Take-Away Points

- A program for education of operational healthcare IT managers should be based on data on what these managers currently do and need to do in the future.
- As healthcare and the role of health IT within it changes, there should be ongoing curriculum review and modification to address the emerging needs.
- Because the academic faculty may not be practitioners, the degree of proficiency and the depth of knowledge of various subjects must be geared to the requirements of the role to which the educational program is aimed, not necessarily to how the faculty themselves were trained.
- Health IT practitioner input to academic programs is valuable when students are being trained for operational health IT roles.
- It is mutually beneficial for health informatics educators to maintain involvement with health informatics professional associations. The associations can provide guidance on curriculum content and networking opportunities for both faculty and students. Health informatics educators' can provide input into professional informatics associations' educational activities.

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Chapter 7
Informatics for the Health Information Technology Workforce

William R. Hersh

Abstract Interest in informatics education took a significant leap with the inclusion of funding for "workforce development" in the Heath Information Technology for Economic and Clinical Health (HITECH) Act, the portion of the American Recovery and Reinvestment Act (ARRA, also known as the "economic stimulus bill") of 2009 devoted to the adoption and meaningful use of health information technology (HIT). The focus of this chapter is on the challenges of trying to create a workforce to meet the informatics and IT needs of a nation that is rapidly changing from a paper medical record environment to electronic health records. The chapter describes the issues that motivated the program, the goals and accomplishments of its components, the lessons learned, and what the future portends after the HITECH funding ends.

Interest in informatics education took a significant leap with the inclusion of funding for "workforce development" in the Heath Information Technology for Economic and Clinical Health (HITECH) Act, the portion of the American Recovery and Reinvestment Act (ARRA, also known as the "economic stimulus bill") of 2009 devoted to the adoption and meaningful use of health information technology (HIT) [1]. Although HITECH was focused mostly on incentives for adoption of the electronic health records (EHR) by clinicians and hospitals, the inclusion of workforce development was a recognition that one of the mechanisms to achieve the HITECH goals was significant expansion of the number of professionals who would could develop, implement, and evaluate HIT. The focus of this chapter is on the challenges of trying to address the informatics and IT workforce development needs of a nation

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_7, © Springer-Verlag London 2014

that is rapidly changing from a paper medical record environment to electronic health records. The chapter describes the issues that motivated the program, the goals and accomplishments of its components, the lessons learned, and what the future portends after the HITECH funding ends.

HIT Workforce Concerns Prior to HITECH

The need for informatics professionals to successfully support implementation of HIT in clinical practice predated the HITECH legislation. In 2008, a workforce analysis was done using the HIMSS Analytics Database [2] a resource consisting of data, self-reported by hospitals, of IT systems, staffing, and other measures [3].

Included in the database is an eight-stage model (labeled 0–7) of adoption, called the Electronic Medical Record Adoption Model (EMRAM) (Table 7.1). Stage 4 of EMRAM includes the use of HIT known to improve clinical outcomes, including clinical decision support and computerized provider order entry [4–6]. The analysis found that IT staffing, measured as full-time equivalent (FTE) per hospital bed, increased successively from Stages 0 through 4. At the time of the analysis in 2008, the proportion of US institutions at Stage 4 or higher was just over 4 %. It was determined from the data that there were currently 108,390 IT FTE employed in hospitals and, extrapolating from the data, if all hospitals moved to Stage 4, a total of 149,174 IT FTE would be required, indicating a need for approximately 40,000 additional FTEs. The study also found that there was a ratio of about one IT FTE per 60 total FTE, which was borne out in a number of other studies from a variety of countries and healthcare institutions [7]. As can be seen in Table 7.1, as anticipated, by 2012 there were increases in the percentages of hospitals who had achieved stages 4–7.

Table 7.1 HIMSS Electronic Medical Record Adoption Model (EMRAM)[a], with proportion from time of 2008 analysis and at present

Stage	Description	2007 (%)	2012 (%)
7	Complete EMR; CCD transactions to share data; data warehousing; data continuity with ED, ambulatory, OP	0	1.8
6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS	0.8	7.3
5	Closed loop medication administration	1.4	12.0
4	CPOE, clinical decision support (clinical protocols)	2.2	14.2
3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside radiology	25.1	41.3
2	CDR, controlled medical vocabulary, CDS, may have document imaging; HIE capable	37.2	11.2
1	Ancillaries – Lab, Rad, pharmacy – all installed	14.0	4.8
0	All three ancillaries not installed	19.3	7.4

[a]Use of EMRAM model and data courtesy of HIMSS Analytics, used with permission

In the meantime, analysis of other categories of the HIT workforce had shown additional anticipated growth and need. An analysis by the U. S. Bureau of Labor Statistics published in 2009 projected growth in health information management (HIM) professionals from about 172,500–207,600 over 10 years, a 20 % increase [8]. In addition, the growing recognition of specific types of HIT personnel, such as the Chief Medical Information Officer (CMIO), was demonstrating the growing numbers and diversity of HIT professional roles [9, 10].

Workforce Inclusion in HITECH

The above data demonstrated significant need and provided the rationale for Section 3016 of the HITECH Act, which stipulated the development of short-term training programs and related activities to train workers to match the needs likely to be generated by the incentives for EHR adoption. ONC developed its Workforce Development Program by surveying the research literature and convening a workshop of approximately 60 educators, HIT leaders, and other experts in the summer of 2009. Based on workforce analyses and expert opinion including the Department of Labor, and various informatics educators and practitioners, it was estimated that a workforce of approximately 50,000 personnel would be needed. Some of these personnel would be needed mainly to assist practices with the implementation of electronic health records. They would be part of a mobile team, who would work with different practices, but would not become permanent staff. Others would likely become permanent staff in hospitals or office practices. These roles, as ONC envisioned them [11–13] are listed below.

Category 1: Mobile Adoption Support Roles

- Implementation support specialist
- Practice workflow and information management redesign specialist
- Clinician consultant
- Implementation manager

Category 2: Permanent Staff of Healthcare Delivery and Public Health Sites

- Technical/software support staff
- Trainer
- Clinician/public health leader
- Health information management and exchange specialist
- Health information privacy and security specialist

Category 3: Healthcare and Public Health Informaticians

- Research and development scientist
- Programmers and software engineer
- Health IT sub-specialist

The first six roles were considered to need short-term training and were appropriate to be taught at the community college level, while the others required more extensive university-based education.

The ONC Workforce Development Program resulted in four separate educational programs that were funded in the spring of 2010 [14].

1. The *Community College Consortia Program* was responsible for training students for the first six roles [11].
2. *Curriculum Development Centers* – Because many of the community colleges did not have curricula in place to address these newly created roles, and also to assure some degree of uniformity across the colleges, five curriculum development centers were funded [15].
3. *Competency Examination Program* – To assess the skills of the community college graduates a national competency exam program was also developed [16].
4. *University-based Training (UBT) programs* – Because the last six roles required more extensive training than those that were being taught by the community college programs, nine universities were funded to develop education and training programs for the last six roles [12].

Community College Consortia

The community college programs were designed to train professionals in the first six workforce roles listed above. Five regional consortia, comprising 82 community colleges in toto, were funded. It was anticipated that a significant number of the people completing these programs would work in regional extension centers (RECs), entities created under the HITECH Act to provide support for EHR adoption, especially in smaller practices and hospitals [17]. These training programs would be different from what most people think of as community college programs (i.e., awarding of associate degrees) in that they would focus on short-term training of people who already had backgrounds in healthcare and/or information technology (IT). (In reality, many community colleges these days have a wide array of programs that provide knowledge and skills to people with specific backgrounds in the workforce.)

The ONC HIT programs were designed to be short-term (six months of full-time study) and offered both in classrooms and via distance learning. It was anticipated that many students in these programs would be unemployed and have time available to study full-time. Programs were encouraged to incorporate plans for sustainability after the HITECH funding ended. The locations of the 82 community colleges are shown in Fig. 7.1.

Some of goals of the community college program have been met while others have not. The program has exceeded its goals of enrollment, with 18,772 graduated as of March 30, 2013 (see Fig. 7.2). An analysis of the first 12,082 graduates of the program through March 30, 2012 found the following backgrounds [18]:

- Health IT – 24 %
- Healthcare (not IT) – 38 %

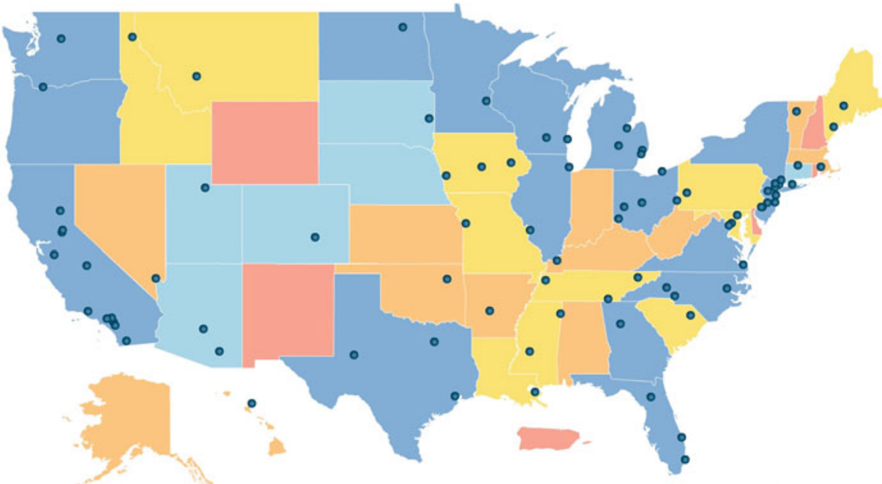

Fig. 7.1 Locations of the community colleges in the Community College Consortia Program (Courtesy of the Office of the National Coordinator for Health Information Technology, used with permission)

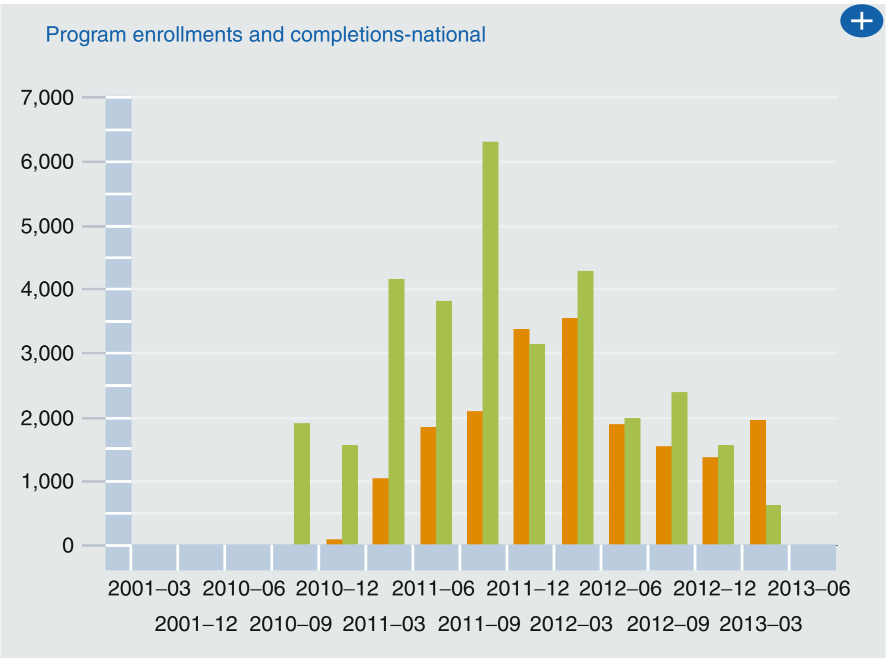

Fig. 7.2 Number of actual graduates and goal for graduates of the ONC Community College Consortia Program. Actual graduates in *green*; goal for graduates in *orange* (Courtesy of the Office of the National Coordinator for Health Information Technology, used with permission)

- IT (not healthcare) – 21 %
- Other/not reported – 17 %

This analysis also found that 15.3 % of the graduates were in rural communities and 27.8 % were ethnic and racial minorities.

One challenge with the program has been that many of the enrolled students are not unemployed, making the six-month course of study difficult. Another challenge for the program has been a lack of awareness on the part of potential employers. For example, one survey of healthcare chief information officers (CIOs) found that only two-thirds were aware of the program's existence [8]. A final difficulty for the program has been that one of its major potential employers, the RECs, needed to hire staff at the same time both the REC and community college programs were starting. As a result, not only were graduates not available when the RECs started their work, but many of the RECs had to design their own training programs to meet their acute needs.

While the future of many community college HIT programs is uncertain with the ending of the HITECH funding, it is likely that many programs will continue, even if they modify their curriculum away from the six-month short-term training model.

ONC HIT Curriculum Development Centers

Because few community colleges had HIT curricula when the HITECH program was launched, an additional program established five Curriculum Development Centers (CDCs) to develop materials for use by these programs. Five universities – Columbia University, Duke University, John Hopkins University, Oregon Health & Science University (OHSU), and The University of Alabama at Birmingham (UAB) – were established as centers, with OHSU additionally being designated the National Training and Dissemination Center (NTDC) to establish the Website for dissemination of the materials and providing training and support in their use. These universities were centers of excellence in informatics education. Four of the five centers had experience not only in on-site informatics programs at the masters and/or doctoral level, but they had been engaged for several years in online informatics education as well. OHSU and UAB had also developed courses for AMIA's 10 × 10 program (see Chap. 8).

The Curriculum Development Centers were provided by ONC with a list of 20 topic areas that needed to be addressed and were expected to produce an initial version of the curriculum so that it was ready for the community colleges by the fall of 2010 when their classes began. Two subsequent revisions were completed by the time the project was slated to end in March of 2012. The topics are listed below and additional details can be found on the healthit.gov website [19]. The topics with an asterisk (*) were expected to include hands-on laboratory exercises.

1. Introduction to Healthcare and Public Health in the U.S.
2. The Culture of Healthcare
3. Terminology in Healthcare and Public Health Settings
4. Introduction to Information and Computer Science
5. History of Health Information Technology in the U.S.
6. Health Management Information Systems
7. Working with Health IT Systems*
8. Installation and Maintenance of Health IT Systems*
9. Networking and Health Information Exchange
10. Fundamentals of Health Workflow Process Analysis & Redesign
11. Configuring EHRs*
12. Quality Improvement
13. Public Health IT
14. Special Topics Course on Vendor-Specific Systems
15. Usability and Human Factors
16. Professionalism/Customer Service in the Health Environment
17. Working in Teams
18. Planning, Management and Leadership for Health IT
19. Introduction to Project Management
20. Training and Instructional Design

The topics were divided among the centers so that each center produced course materials for four of the topics or what came to be called curriculum "components." As described on the ONC website, each component includes "slide-based lectures with audio narration and transcripts, instructor manuals, learning activities, and self-assessment questions with answer keys and hands-on computer lab-based experience using VistA for Education electronic health record (EHR) software" [20]. Each component was equivalent to a whole course and the components were divided into units which could be used for individual lessons.

The plan for the curriculum was developed collaboratively by the five centers and ONC to address the workforce roles that ONC had identified. A matrix shown in Fig. 7.3 of how the components mapped to the roles was developed as part of that collaboration [21]. Another view of the materials, in the words of the architect of the program (Charles Friedman, PhD, who was then Chief Science Officer of ONC), was that these materials were a buffet, in that users could pick and choose what they wanted. They were also free to use them "as is" or "out of the box," or to modify or improve them as necessary for their particular use.

The use of VistA for Education is a unique feature of the curriculum. VistA is the electronic health record system used by the U.S. Department of Veterans Affairs and three components included laboratory exercises using VistA. The intent was not to

Matrix of HIT Workforce Curriculum Components by Role
"Set Table"

Curriculum Components			HIT Workforce Role											
Component #	Component Name*	Core to how many roles?	Clinician/Practitioner Consultant		Implementation Managers		Implementation Support Specialist		Practice Workflow and Information Management Redesign Specialist		Technical/Software Support		Trainer	
Student Background:			Health Care	IT**	Health Care	IT	Health Care	IT	Health Care	IT	Health Care	IT	Health Care	IT
Components														
1	Introduction to Health Care and Public Health in the U.S.	1	4	4	4	2	4	2	4	2	4	2	4	1
2	The Culture of Health Care	3	4	4	4	1	4	2	4	1	4	2	4	1
3	Terminology in Health Care and Public Health Settings ***	2	2	4	2	2	2	1	2	1	2	2	2	2
4	Introduction to Information and Computer Science	4	2	4	3	4	1	4	1	4	1	4	1	4
5	History of Health Information Technology in the U.S.	1	2	4	1	2	2	3	2	2	2	2	2	2
6	Health Management Information Systems	3	1	4	2	2	2	2	1	2	2	2	1	2
7	Working with Health IT systems	3	1	4	3	3	1	1	2	2	1	1	2	3
8	Installation and Maintenance of Health IT Systems	2	3	4	2	2	1	1	3	3	1	1	3	3
9	Networking and Health Information Exchange	2	2	4	2	3	1	1	2	2	1	1	2	2
10	Fundamentals of Health Workflow Process Analysis and Redesign	3	1	4	1	1	3	2	1	1	3	3	2	2
11	Configuring EHRs	2	3	4	2	3	1	1	2	3	1	1	3	3
12	Quality Improvement	2	1	4	2	2	2	3	1	1	3	3	2	2
13	Public Health IT	0	2	4	3	3	3	3	3	3	3	3	2	2
14	Special Topics Course on Vendor-Specific Systems	2	3	4	2	2	1	1	3	3	1	1	2	2
15	Usability and Human Factors	2	2	4	3	3	2	2	1	1	2	2	1	1
16	Professionalism/Customer Service in the Health Environment	2	3	4	2	2	3	3	2	2	1	1	1	1
17	Working in Teams	1	2	4	1	1	3	3	2	2	3	3	2	2
18	Planning, Management and Leadership for Health IT	2	1	4	1	1	4	4	3	3	4	4	3	3
19	Introduction to Project Management	1	3	4	1	1	3	3	2	2	4	4	3	3
20	Training and Instructional Design	1	4	4	3	3	4	4	4	4	4	4	1	1
	Number of Core Components per Role		5	n/a	5	5	6	6	5	5	7	6	5	5
	Number of Secondary Components per Role		7	n/a	8	8	5	5	8	8	4	6	9	9

Scale for weighting importance of component to role:

1	core = all or most units required for role
2	secondary = some units may be required for role
3	tertiary = optional; enrichment material
4	not relevant to role and/or student background

* Any of these components could be waived if the student can demonstrate this knowledge upon admission.
** The Clinician/Practitioner Consultant requires a background in health care.
*** For the Terminology component, the recommended units for students with a health care background are those that cover IT terminology.

Fig. 7.3 Matrix of HIT Workforce Curriculum Components by Role (Courtesy of the Office of the National Coordinator for Health Information Technology, used with permission)

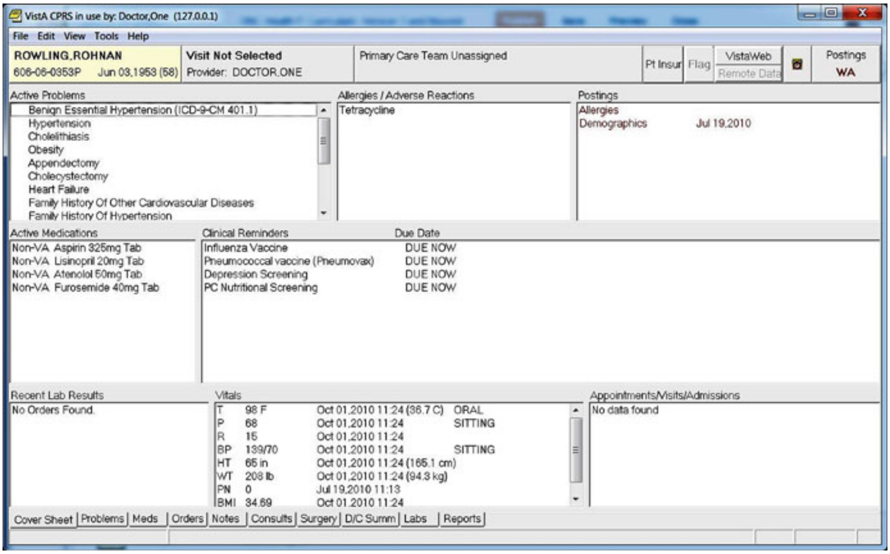

Fig. 7.4 Screen shot from the VA VistA EHR used by Components 7, 8, and 11 of the ONC HIT Curriculum (Courtesy of the ONC National Training and Dissemination Center, used with permission)

teach the use of the VistA system per se, but to provide the students with hands-on experience with functions that are common to most certified electronic health record systems. A screen shot from the main patient summary screen is shown in Fig. 7.4.

The additional roles for OHSU as part of their NTDC responsibilities included hosting a training session for the community college instructors on the use of the materials in the summer of 2010, providing support for users of the materials, and most importantly, housing the materials on the NTDC Website for users to download [22]. Downloading can be done by anyone after setting up a free login to the site. Each of the components, or each of the units within each component, can be downloaded from the NTDC Website. A fully functioning version of VistA is also available for download, although it only runs on computers running the Windows operating system. The materials are distributed under a Creative Commons Attribution-Non Commercial-ShareAlike License.

The amount of materials developed is very extensive as shown in Table 7.2. In toto, there were over 1,400 documents, and almost 10,000 PowerPoint slides. The total amount of lecture time was over 136 h. There is also a topic index and a search engine to help educators, who are the main target audience, navigate and find appropriate materials. As of the spring of 2013 almost 10,000 individuals from over 70 countries have registered with the NTDC for use of the materials. A study by the chapter author and colleagues included a description of the development of the curriculum and an evaluation by the users [23]. Results showed that users were generally pleased with the materials and appreciated the resource, but found that for optimal use they had to adapt the materials to their meet their specific needs.

Table 7.2 Files and sizes for the components of Version 3 of the ONC HIT curriculum

Component	Word files	Word files size	PPT files	PPT slides	PPT file size	MP3 files	MP3 files size	MP3 time
1	81	7.5	39	774	24.4	39	268.6	9:46
2	78	3.5	36	687	19.9	36	288.3	10:29
3	87	5.3	23	507	24.4	23	215.6	5:14
4	93	4.1	38	862	42.7	38	349.5	12:43
5	80	3.7	24	626	31.3	24	317.4	6:43
6	59	2.1	17	370	9.4	17	239.5	6:25
7	87	17.8	18	209	21.3	19	167.7	5:41
8	60	2.6	16	347	13.4	16	234.8	6:06
9	70	3.0	29	738	44.5	28	362.1	10:08
10	69	3.2	27	621	25.6	27	309.2	9:08
11	48	10.8	15	260	10.1	15	124.3	4:31
12	76	4.0	26	468	42.9	26	258.8	6:53
13	82	3.7	20	624	67.3	22	203.9	7:25
14	40	1.6	8	204	13.9	8	60.5	2:12
15	74	3.3	26	738	86.5	26	236.4	7:22
16	51	2.4	15	337	12.9	15	148.1	3:28
17	72	6.3	15	265	22.9	15	184.7	4:52
18	61	3.2	21	483	31.8	20	216.5	5:08
19	89	6.6	27	494	31.7	27	300.2	7:57
20	46	2.0	14	360	35.4	14	134.6	3:45

While the grant funding period for the Curriculum Development Centers was expected to end in April, 2012, the awarding of no-cost extensions to the five centers extended the project to March, 2013. The plans for the materials beyond that time have not been determined, although they will continue to be available on one or more websites.

Competency Examinations

The ONC also established a program of HIT competency examinations for individuals completing the community college programs, and members of the workforce with relevant experience or others types of training, for the six community college workforce roles. An Advisory Council was formed that included representatives from the Curriculum Development Centers, the Community College Consortium as well as others in the health IT industry. The exam developers aimed to have more than 80 % of the questions based on content in the curricular materials. The other 20 % came from a workforce survey and analysis of individuals who were performing the roles in their current jobs. The HIT Professionals exams opened to individuals in May, 2011 [24]. The six exams each consist of 125 multiple-choice questions to be completed in three hours. Free exam vouchers, enabling individuals to take their first exam at no cost, were made available for students trained through the Community College Consortia program and for other individuals with relevant experience, training, or education in healthcare or IT. In the initial round of beta testing, from 60 to 76 % (depending on the role) of those taking the exam passed it. Overall, results showed variable performance across community colleges, across roles, and across curriculum components. The feedback from the examinations is a useful tool to assist the Curriculum Development Centers in improving their materials and the Community Colleges in improving their teaching and curriculum organization.

University-Based Training Programs

The final part of the ONC Workforce Development Program was the UBT program. This program funded training for professionals in the latter six workforce roles (see above) in one/two year certificate or master's degree programs. A total of nine universities or consortia of universities were awarded funding for training a total of 1,685 students across all of their programs. Some UBT programs only offered training in some of the workforce roles, while others provided training in all. Five of the UBT programs described their programs and students in the ONC Health IT Buzz Blog:

- OHSU [25]
- Indiana University [26]
- A consortium of Duke University and the University of North Carolina at Chapel Hill [27]
- A consortium of Columbia University and Cornell University [28]
- The Texas PURE-HIT consortium, led by Texas State University-San Marcos in collaboration with the University of Texas at Austin College of Natural Sciences and the University of Texas Health Science Center at Houston School of Biomedical Informatics [29]

The four other programs have not yet been profiled in the ONC blog. One is the UP-HI consortium that includes the University of Minnesota-Twin Cities, the University of Minnesota-Crookston, and the College of St. Scholastica. The other three UBT programs are from Johns Hopkins University, George Washington University, and University of Colorado Denver College of Nursing.

The program at OHSU typifies the UBT program. The ONC funding made it possible for the OHSU program to provide financial aid for their previously existing Graduate Certificate and Master of Biomedical Informatics programs. All six workforce roles were covered, with specific required courses for each. In the first two years of the three-year program, OHSU filled all of the 135 certificate slots and the 13 master's slots. Most, if not all, of the other UBT programs adapted some of their existing educational programs to the task of meeting the needs for training for the identified roles.

Lessons Learned

The ONC Workforce Development Program has added substantial new resources and capacity for training and expanding the HIT workforce. It has led to new programs and additional faculty. In addition, the curriculum materials will be valuable not only for community colleges but for other programs as well. Because all the materials are provided in a source format, various educational programs will not have to start from scratch in developing their own curricular materials and will be able to use or adapt what the ONC program has provided.

While the UBT programs developed their own curriculum materials the community colleges were required to use the materials from the Curriculum Development Centers, although they were free to select parts of them and adapt the materials to meet their needs. In hindsight, however, the tight timeline and the close coupling of the competency exam to the curriculum, wound up limiting the flexibility and many of the colleges chose to use the materials as they received them.

Probably the biggest limitation of the program was the short-term nature of its funding, due to the fact that it came from the economic stimulus program. Not only did the program have too short of a start-up phase, other HITECH programs – especially the Regional Extension Centers (REC) program – were begun at the same time and had to start hiring and training personnel before the workforce programs could start producing graduates. An ideal sequence would have been to fund the Curriculum Development Centers first, then the community colleges, and to let the colleges provide feedback on the first version of the curriculum before the curriculum development centers produced the second version. If the Regional Extension Centers were funded shortly before the first cohort of the community college trainees graduated, the curriculum materials could be used to train the REC staff and the RECs could provide internships and later employment for the community college graduates. Finally, once the curriculum was more solidified, the competency exam could be developed to evaluate the graduates.

Also related to the short-term nature of the program was an inability to meet the desire of employers for new hires with substantial work experience. This, of course, is not a problem that can be easily addressed, since many who pursue educational programs do not have prior work experience in the field where they are pursuing new studies, and the aim of the program was, after all, to bring more new people into the field.

An additional problem has been a lack of awareness of the program. A 2012 survey by the College of Healthcare Information Management Executives of healthcare chief information officers (CIOs) found that about 67 % of respondents reported that their organizations were experiencing personnel shortages [8]. About 71 % said IT staff shortages could jeopardize an enterprise IT project, while 58 % said the shortages would definitely or possibly affect meeting meaningful use criteria for incentive funding. About 85 % also expressed concerns about being able to retain current staff. The survey also found a lack of awareness of ONC Workforce

Development Programs. Only 67 % were aware of the programs, with 12 % of those respondents reporting that they had hired graduates from them (Unfortunately the survey did not distinguish knowledge of and hiring from community college versus university based programs) [11, 12].

The Future

Although the funding for the ONC Workforce Development Program ended in 2013, the need for clinical informatics professionals is unlikely to abate. If anything, the need for these professionals will increase, although the scope of their work will likely transition from implementing systems to making the most effective use of data and information within them [30].

The ONC Workforce Development Program has benefitted not only those directly funded by its grants, but also the entire field of clinical informatics through raising awareness of the value of the field as well as providing curricular materials available to existing and new programs. There will also be increasing awareness of professionals in the field through the increasing number of certifications, starting with the new clinical informatics subspecialty in medicine [31] (See also Chap. 4). There will be other opportunities for certification, not only for health professionals, but also those from other fields. As new forms of healthcare delivery, along with a learning health system [32], take shape, the need for processionals who help capture, analyze, and act on such data will only increase.

Key Take-Away Points

- The ONC Workforce Development and Regional Extension Center programs have added substantial capacity in educational programs, curricular materials, and health IT professionals with expertise in EHR implementations.
- The development of a set of materials rather than a tightly sequenced curriculum allowed the materials to be used for multiple purposes by educators at different levels.
- Collaboration among educators from various sectors requires adapting to the differences in cultures, students, and expectations, but such collaborations can produce a robust educational experience.
- The short-term nature of the program and the lack of experience of graduates have led to some mismatch between employer needs and the value the graduates can provide.
- There will be additional challenges in training the workforce going forward as the needs of employers shift from implementation of systems to being able to leverage the data in them.

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Chapter 8
Online Continuing Education in Informatics: The AMIA 10 × 10 Experience

William R. Hersh

Abstract This chapter describes the background and current status of the AMIA 10 × 10 continuing education program. AMIA 10 × 10 is organized by the American Medical Informatics Association (AMIA) program in partnership with universities around the U.S. It was started in the mid 2000s with the goal of training 10,000 informaticians by 2010. It was started to address the growing need for informatics education that was not degree-based and is a model for informatics continuing education programs. The program at Oregon Health & Science University was the first 10 × 10 program and its curriculum is described in some detail to illustrate how the 10 × 10 programs are organized. The chapter concludes with a description of how the program has grown over the last seven years.

While the educational pathway for a career in informatics will increasingly involve obtaining an academic degree or other formal training, there is also a need for education short of a full degree for a variety of audiences. While a variety of these educational experiences of lesser depth have been developed in recent years, one of the most visible efforts has been the 10 × 10 ("ten by ten") program of the American Medical Informatics Association (AMIA). This chapter will present an overview of the 10 × 10 program, provide a detailed description of the original and still most-attended course in the program offered by Oregon Health & Science University (OHSU), describe the history of the program, and review some data on its enrollment and acceptance.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_8,

Background of the 10×10 Program

The seed of the 10×10 program was planted by then-President of AMIA Dr. Charles Safran, who had been assessing both the need for informaticians and the ability of informatics programs to increase their capacity. Dr. Safran began advocating that each of the nearly 6,000 hospitals in the United States employ at least one physician and one nurse who had some formal training in informatics [1]. This led AMIA to undertake an analysis of what it might take to develop and market such training, leading to the realization that it would require resources that the organization did not have.

In the meantime, a number of academic informatics programs, including the one at OHSU led by this author, had started offering courses, certificates, and even degrees via distance learning. The program at OHSU made its first foray into distance learning in 1999, when we received repeated queries as to whether our courses could be taken online. The first course we converted to an online format was the introductory course taken by all students in the clinical informatics track of our biomedical informatics graduate program [2]. This course, entitled *Introduction to Biomedical Informatics*, broadly surveyed the field for those who planned to pursue further study in the field as well as those who just wanted an in-depth overview. The online course was a one-quarter academic course that made use of voice-over-PowerPoint narrated lectures (two–three hours per unit, broken down into 15–25 min segments), reading assignments, threaded discussion forums, and multiple-choice homework quizzes.

Dr. Safran queried informatics educational programs as to how much they could increase their capacity if demand warranted. While most programs felt they could achieve a two to threefold increase in capacity, this author, noting the scalability of distance learning, replied that given enough lead time to hire sufficient faculty and support staff, expansion could be literally unlimited. On a whim, he told Dr. Safran that he was confident of meeting his goal of having the capacity to train one physician and one nurse in each U.S. hospital by the end of the decade (2010). This led the author to suggest the title of the program as “10×10”, with the goal of training 10,000 individuals in informatics by the year 2010. AMIA and OHSU collaborated on a pilot course for what would become the AMIA 10×10 program.

Because the OHSU course already existed, it was relatively straightforward to re-configure parts of it for 10×10. Essentially the same curricular materials as the OHSU graduate course were used, with some modification of the first part of the first unit’s lecture. It was also decided to culminate the course with an in-person session that would take place at various AMIA symposia. This would also allow the students to further enhance their learning with scientific presentations and, in the case of the annual fall symposium, avail themselves to one to two tutorials.

The course would be offered as a continuing education course, with continuing medical education (CME) credits offered that AMIA was accredited to provide. Because it was a continuing education course, the final examination of the graduate course was not required. However, since some taking the course might wish to continue on to further study in informatics, it was decided to offer the final exam optionally, and award OHSU graduate credit to those who scored a grade of B or better. This would enable those desiring further study in the field to easily continue at OHSU or any other program that would give credit for completing the course. (Another reason for some to take the optional final exam was that tuition reimbursement, usually from an employer, required students to have an official transcript with a letter grade.)

The discussion to implement the course began in early 2005, with the course announced in the late spring and started in July. A total of 51 individuals started the first course, with 44 completing it and most attending the AMIA 2005 Annual Symposium [3]. All 17 individuals who took the final exam scored a grade of B or better. The success of the first offering led to planning for additional offerings, with a second course offered in early 2006 that would end around the time of the AMIA Spring Congress. In 2006, AMIA began enlisting other universities to partner with them on 10×10 courses.

The original course and still the one with the largest enrollment has been the course offered by OHSU. This course has a broad focus on biomedical informatics, with a sub-focus on clinical (i.e., healthcare) informatics. Two other general courses which have had the largest enrollment after OHSU, are those offered by the University of Alabama at Birmingham (UAB) and the University of Illinois at Chicago (UIC). While the same general content is covered in all three of the courses, there is more of a management emphasis in the UAB courses and more of an implementation focus in the UIC 10×10.

Additional 10×10 courses have been developed in more specialized areas of the field by other universities, including the following:

- Translational bioinformatics – Stanford University
- Public health informatics – University of Utah
- Clinical research informatics – Ohio State University
- Usability – University of Texas Houston Health Sciences Center

These courses have had smaller enrollment than the general overview courses, but serve a vital niche for certain audiences. Some additional general offerings have appeared in recent years, including those from Nova Southeastern University School of Osteopathic Medicine, the University of Kansas Medical Center, and the University of Minnesota.

Audiences

Who would be an audience for informatics education short of a full degree that is comparable to an introductory graduate-level course? One audience is those who have worked in the field for a long time but never had any formal training. While a full educational program might serve them better, a single overview course like 10×10 may be all for which they have time. Another audience is someone who has informatics-related work in their career but is not predominantly an informatician.

This might include those who are clinical champions (i.e., have involvement in IT implementation in their clinical settings) or researchers whose study includes informatics interventions. An additional audience for a single course is someone who wants to "test the waters" with a single course before committing to an entire program of study. All of these types of individuals have been present in 10×10 courses.

OHSU Course

To give a sense of the content and learning experience of the 10×10 program, we will present an overview of the OHSU course. The other general courses have somewhat similar curricula, while the more specialized courses are focused in specific areas. All of the courses are completely online, with the exception of the one-half to 1 day in-person session at the end of the course.

The OHSU 10×10 course, as well as many of the other 10×10 courses, is offered in two parts. The first part is a 10-unit Web-based component that is provided through readings, voice-over-PowerPoint lectures, interactive discussion, and self-assessment tests. A detailed outline of the content is provided in Table 8.1. The second part is an intensive one-day in-person session that brings attendees together to integrate the material, allow presentation of course projects, and meet leaders in the field as well as other students. This session takes place at one of the annual AMIA conferences, which also facilitates students attending a national professional informatics meeting

As noted previously, the OHSU course is an adaptation of its online *Introduction to Biomedical and Health Informatics* class currently taught in the OHSU biomedical informatics education program [4]. This survey course provides a broad overview of the field, highlighting the key issues and challenges for the field. The course is taught in a completely asynchronous manner, i.e., there are no "scheduled" classes and there is no scheduled time that a student must be online. However, students must keep up with the course materials so they can benefit from the interactive discussion with faculty and other students. Other 10×10 programs have also adapted existing introductory graduate courses to meet the needs of the 10×10 students. The course uses the following teaching modalities:

- Voice-over-PowerPoint lectures – These are delivered using the Flash plug-in, which is freely available and already installed in almost all Web browsers. A screen shot of a lecture is shown in Fig. 8.1.
- Interactive threaded discussion – Students engage in interactive discussion on important issues using online discussion forums.
- Reading assignments – The course uses supplemental readings as necessary. In addition, students are pointed to key documents, reports, and papers from the field.

Table 8.1 Curriculum outline of the Oregon Health & Science University (OHSU) 10×10 Course

1. Overview of field and problems motivating it
1.1 What is biomedical and health informatics?
1.2 A discipline whose time has come
1.3 Problems in healthcare motivating biomedical and health informatics
1.4 Who does biomedical and health informatics?
1.5 Seminal documents and reports
1.6 Resources for field – organizations, information, education
2. Biomedical computing
2.1 Types of computers
2.2 Data storage in computers
2.3 Computer hardware and software
2.4 Computer networks
2.5 Software engineering
3. Electronic and personal health records (EHR, PHR)
3.1 Clinical data
3.2 History and perspective of the health (medical) record
3.3 Definitions and key attributes of the EHR
3.4 Benefits and challenges of the EHR
3.5 EHR examples
3.6 Personal health records
3.7 Nursing informatics
4. Standards and interoperability; privacy, confidentiality, and security
4.1 Standards: basic concepts
4.2 Identifier and transaction standards
4.3 Message exchange standards
4.4 Terminology standards
4.5 Natural language processing
4.6 Privacy, confidentiality, and security: basic concepts
4.7 HIPAA privacy and security regulations
5. Meaningful use of the EHR
5.1 Patient safety and medical errors
5.2 Healthcare quality
5.3 Clinical decision support (CDS)
5.4 Computerized provider order entry (CPOE)
5.5 Health information exchange (HIE)
5.6 HITECH, ARRA, and achieving meaningful use
6. EHR implementation and evaluation
6.1 Clinical workflow analysis and redesign
6.2 System selection and implementation
6.3 Evaluation of usage, outcomes, and cost
6.4 Clinical research informatics
6.5 Public health informatics
6.6 Analytics and business intelligence

(continued)

Table 8.1 (continued)

7. Evidence-based medicine (EBM)
7.1 Definitions and application of EBM
7.2 Interventions
7.3 Diagnosis
7.4 Harm and prognosis
7.5 Summarizing evidence
7.6 Putting evidence into practice
7.7 Limitations of EBM
8. Information retrieval and digital libraries
8.1 Information retrieval
8.2 Knowledge-based information
8.3 Content
8.4 Indexing
8.5 Retrieval
8.6 Evaluation
8.7 Digital libraries
9. Imaging informatics and telemedicine
9.1 Imaging in healthcare
9.2 Modalities of imaging
9.3 Digital imaging
9.4 Telemedicine: definitions, uses, and barriers
9.5 Efficacy of telemedicine
9.6 Patient-provider communications
10. Translational bioinformatics and personalized medicine
10.1 Bioinformatics – the big picture
10.2 Overview of basic molecular biology
10.3 Important biotechnologies driving bioinformatics
10.4 From clinical genetics and genomics to personalized medicine
10.5 Bioinformatics information resources
10.6 Translational bioinformatics challenges and opportunities

- Homework/quizzes – Each of the units is accompanied by a ten-question multiple-choice self-assessment that aims to have the student apply the knowledge from the unit.

The online part of the course is accessed via a learning management system. Students are expected to keep up with the materials each week and participate in ongoing discussion. They are instructed to anticipate spending four to eight hours per unit on the course. All online activities are asynchronous, so there is no specified time that a student must be online.

The course also requires a project. In the OHSU course, students identify an informatics problem in their local setting (e.g., where they practice or work) and propose a solution based on what is known from informatics research and best practice. In other 10×10 programs, project topics may be assigned or students can pick a topic of their choosing. The project must be submitted before the in-person session at the end of the course. If a student does not have access to a healthcare setting,

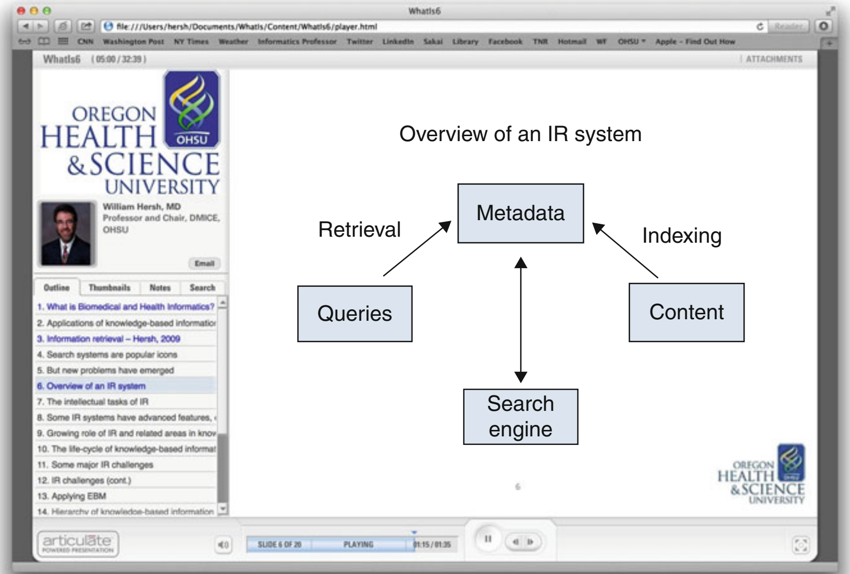

Fig. 8.1 Screen shot of narrated lecture

they can do the project in another setting, such as a company or organization. The details of the assignment include:

- Assess some local setting (work environment, practice, hospital, etc.) to identify an informatics-related problem or a problem that could be improved by an informatics solution.
- Using the knowledge of research and best practices in informatics acquired in the course, propose a solution to the problem.
- The problem and solution are written into a two to three page document that should include references that justify the framing of the problem and the proposed solutions.
- The problem and solution are also presented at the in-person session.

The course is also designed to make it easy for students to pursue further graduate study. While the OHSU 10×10 course does not require a final examination, students can optionally take one, with those obtaining a grade of B or better getting automatic credit for the introductory course in the OHSU graduate program upon enrolling in the program. Over 95 % of those who have taken the exam have received a grade of B or higher. Other 10×10 programs have similar mechanisms to allow students to exempt from the introductory graduate course at the specific site, even if the program does not provide graduate credit for the course.

Other 10×10 offerings use variations on this theme. Some have a few synchronous sessions for special lectures or demonstrations, student presentations or other reasons.

Some use team exercises where students collaborate virtually to address a real or simulated informatics problem that allows them to apply the concepts taught in the class.

Growth of the 10 × 10 Program

OHSU has partnered with other organizations to offer the course whose ending would coincide with different meetings and, as such, attract different audiences. The first partnering organization was the California Healthcare Foundation, with this offering starting in the fall of 2005 and having its in-person session at CHCF headquarters in Oakland, CA in early 2006. This led to a succession of joint offerings with professional societies and other organizations, including the American College of Physicians, the Scottsdale Institute, the Society for Technology in Anesthesiology, the American College of Emergency Physicians, and the Academy of Nutrition and Dietetics. All of these offerings had their culminating in-person sessions at their professional meetings, with the exception of the partnering with the Scottsdale Institute, which culminated at an AMIA meeting. The partnerships with the American College of Emergency Physicians, and the Academy of Nutrition and Dietetics have been and continue to be sustained over multiple years, mainly due to involvement of informaticians from those organizations.

The OHSU course has been delivered in additional ways. One consisted of embedding the course in a larger yearlong program for nursing executives at Mayo Clinic. The final in-person session was held at Mayo Clinic and included other training activities while on-site. Another offering of the course has been offered in partnership with Gateway Consulting of Singapore. While most students enrolled in the Singapore offerings have been from that country, a variety of others from nearby countries in Southeast Asia have enrolled. The Singapore offering has two in-person sessions, one attended by the lead instructor remotely via Skype and the other attended by him in person. This offering of the course led AMIA to name the international programs "i10 × 10" courses.

Another partner in the i10 × 10 program has been the Hospital Italiano of Buenos Aires (HIBA) in Argentina. A HIBA faculty member was a student in the first OHSU offering, and she put together a team to translate the OHSU version into Spanish. While the first offering was a near-direct translation, the course has since evolved in content to provide a more Latin American perspective [5]. Some of these international offerings are also discussed in Chaps. 13 and 14.

Evaluation

The 10 × 10 program has been evaluated in a number of ways. One simple but illustrative evaluation is to note the continued enrollment in the program, especially the general overview courses. While the program did not achieve its tag-line

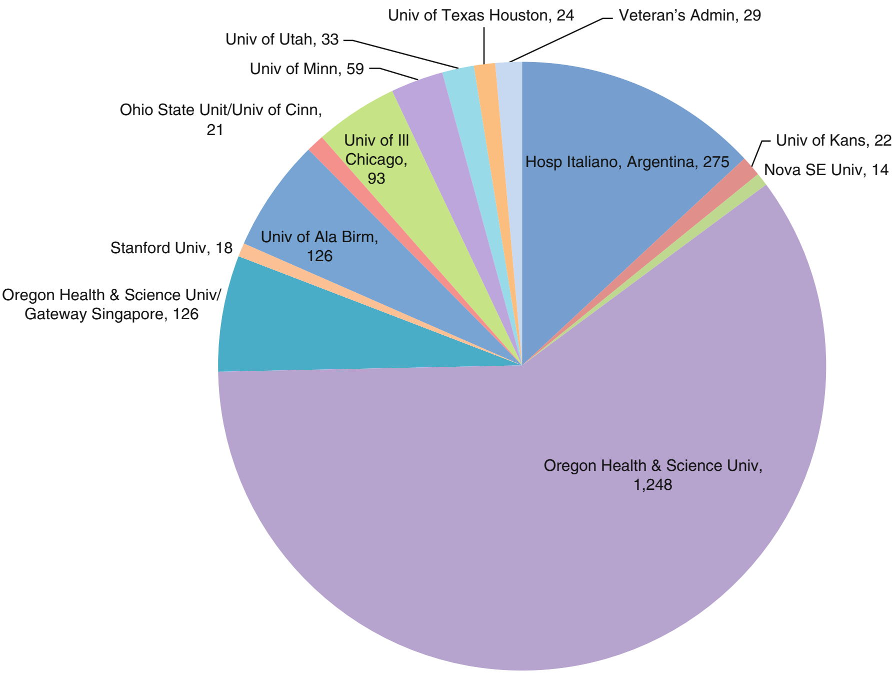

Fig. 8.2 Distribution of students completing 10×10 courses from 2005 to 2012

goal of 10,000 trained by 2010, a total of 1,257 completed a course by the end of 2010, with 999 coming from the OHSU offerings. (Since there was continued interest in the program at the end of the 2010, the tag line was changed to "10,000 trained in 10 years.") At the end of 2012, a total of 2,024 people had completed a course, with the distribution among the courses shown in Fig. 8.2. (The total completing the HIBA course is even higher, with 613 people completing it before the i10×10 name was used. The figure also separates out those completing the U.S.-based OHSU course from the Singapore i10×10 offering that consists mainly of the OHSU course.)

The first formal evaluation of the course was done after the initial offering in 2005 [3]. A total of 44 of the 51 students completed the evaluation. In general, their satisfaction was very high, with 12 of 13 measures of course and instructor satisfaction rating above 4.0 on a 1 (low) to 5 (high) scale, and the final measure of the in-person session rating at 3.86. The largest occupational group in the course was physicians (24), followed by IT professionals (7), nurses (5), and 1–2 each of pharmacists, statisticians, laboratory technicians, and health information managers.

A more thorough evaluation of all OHSU courses to date by the end of 2007 was completed as well [6]. Of the 170 graduates eligible for the study, 79 (47 %) completed the 24-question open-ended survey. The results found a 2:1 ratio of men to women, with a preponderance (72 %) in the 40–59 age group. Just under half of the respondents stated that the course enhanced their career in some fashion. A majority

(66 %) indicated they planned to pursue further study in the field, with 23 % already enrolled in a graduate program, mostly at OHSU. While 67 % of respondents said the online nature of the course was a strength, 14 % indicated there was too little interaction while 27 % had hoped for more.

An evaluation of the entire AMIA 10×10 program through the end of 2010 was completed in 2011 [7]. Invitation to participate in the study was sent to 1,204 graduates, 328 (27 %) of whom took part. Due to heavy OHSU enrollment in the program at large, a total of 78 % of respondents to this survey had completed the OHSU course. The participants were found to reside in 45 U.S. states as well as 13 countries beyond the U.S. Similar to the previous studies, satisfaction with the course was relatively high, i.e., most ratings were between 4 and 5 on a 1 (low) to 5 (high) scale. Many graduates reported the course content and/or experience helping to advance their career goals in informatics.

A final measure of success of the program comes from the annual Gartner survey of chief medical informatics officers (CMIOs) [8]. This annual report of physician informatics leaders queries a variety of attributes of CMIOs, such as clinical and educational backgrounds, clinical vs. informatics time, salaries, and reporting relationships. When asked sources of additional training pursued by CMIOs, the most common answer after "none" (30 %) was the 10×10 course (19 %), followed by Master of Business Administration (16 %), master's degree in informatics (10 %), and Master of Public Health (7 %).

Lessons Learned

The OHSU 10×10 experience found that enrolled students are every bit as engaged in the course as those in the regular graduate program at OHSU. One challenge is that many are currently employed in busy clinical or informatics jobs, making the time commitment difficult. This is a challenge that other 10×10 and other continuing education programs face when there is a significant amount of material and the audience members are engaged in full-time employment. The decision was made to de-compress the course with a pattern of two weeks of materials posted followed by a free week of no new materials posted. However, some students do fall behind, and those who fall too far behind are usually not able to get caught up to finish the course in time.

Those students who do work in informatics position have commented that they find that the course materials are highly practical and often applicable to their jobs. Whether previously exposed to the field or not, almost all students appreciate both the "big picture" of the field presented as well as an introduction to its language. (This author has always found it ironic that many who work in informatics have little formal training, and often seek training in 10×10 or even full graduate programs to learn material that one might believe would be required before taking such positions in the first place!)

Another challenge in teaching the course is the diverse backgrounds and careers of those enrolled in the course (a problem probably inherent to all informatics education). From physicians and nurses to administrators and IT personnel, it is a challenge to make the materials pertinent and challenging to such a diverse group of students. This is partially overcome through the discussion forums, where complementary backgrounds are valued and efforts are made to engage everyone. Chapter 2 discusses other challenges of online education and strategies for managing them.

Conclusions and Future Directions

The 10×10 course has provided a valuable educational experience for those desiring to obtain informatics education short of a certificate or degree program. While not a substitute for such programs, the course has allowed a variety of types of individuals to advance their careers in the field. By being part of larger programs, however, the course has also served as a stepping stone to more education. Although demand for the course continues to justify its offering, it will be interesting to see how it evolves as the field itself continues to grow and change.

Key Take-Away Points

- There is an important role for continuing education programs in informatics, especially for students for whom a formal graduate program is not feasible.
- The use of asynchronous and online learning is an effective means to provide such education.
- If the program is based on a graduate educational program, some adaptations have to be made to accommodate the needs of the full-time employed student.
- Courses short of full certificate or degree programs, like the 10×10 program, provide a substantial overview as well as entry point to further study in the field.
- Courses such as 10×10 can bring attendees to academic informatics and related conferences to also further their education and perspective.

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Part III
Informatics Education for Other Health Professionals

Chapter 9
Educating the Informatics-Enabled Physician

H. Dominic J. Covvey

Abstract There are multiple pathways a clinician can take for a career in informatics. Some choose to focus on research and development, others are leaders in applied informatics, but all clinicians, whether they dedicate themselves to informatics or not, need a set of competencies to survive in an electronic world. This chapter focuses on the competencies that all physicians who use information and communication technologies need in order to become what we are calling an informatics-enabled physician. The chapter outlines the key tasks that the informatics-enabled physician must be able to perform, the competencies required and the role of the e-Health team in which the physician is a crucial participant.

Over the last several decades, the potential positive impact of information and communications systems has become increasingly obvious. This presents a challenge to all physicians to become capable of at least using these systems or, potentially, of being involved in deploying them.

The discipline of Health Informatics, also referred to as biomedical informatics, medical informatics, or clinical informatics, has emerged from the realization of the significance of information-related challenges in healthcare and the realization of the potential of information systems to address these challenges. These realizations have, in turn, led to an understanding of the need to define systems-related competencies (knowledge, skills, experience, attitudes and values) and to imbue a wide variety of professionals, especially physicians, with the concepts of this discipline.

The discipline of Health Informatics (HI) is expressed in three major career paths or channels. The first channel is the realm of scientists and theoreticians who conceptualize both significant health information-related challenges and the new tools and methodologies to address these challenges. Some have called this channel

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_9, © Springer-Verlag London 2014

Research and Development Health Informatics (RDHI). The National Library of Medicine (NLM) training programs described in Chap. 3 focus on this channel. The second channel is a more prevalent and practical one related to the selection, deployment, use and evaluation of the tools and methods developed by the RDHI scholars. This channel has been described as Applied Health Informatics or e-Health (electronic Health). Those who work in this channel elect to become directly involved in implementing information and communications systems in healthcare environments (see Chaps. 4, 5, 6 and 7 for additional discussion of these roles). Typically, they are members of the team of professionals that serves an institution, often in an Information Services Department (ISD) or in a liaison capacity between other departments and the ISD. The third channel is the one in which most clinicians have found or, inevitably, will find themselves. What is involved here affects every physician and challenges him or her to become sufficiently knowledgeable about systems and appropriately skilled in their use. With appropriate competencies, the physician will be able to function at the level of productivity that has become necessary for efficient and effective healthcare. We have called this channel Clinician Health Informatics and the individual, the Informatics-Enabled Physician.

Defining Competencies

We have undertaken a number of efforts to define the competencies required in each of these three channels. Our fundamental work is available in the document 'Pointing the Way: Competencies and Curricula in Health Informatics' [1]. This project was carried out over two years by approximately 100 Canadian and American representatives of various stakeholder groups, including educators, clinicians (predominantly physicians and nurses), healthcare industry professionals (from hospitals, clinics and private product and services companies), leading health informaticians and students [2]. Our process engaged three teams, of about 20 individuals each, selected from the participants, with the remainder acting as reviewers and providing periodic feedback.

Each of the three teams addressed one of the channels previously cited: Research and Development Health Informatics, Applied Health Informatics or Clinician Health Informatics. Each team began with a straw version of the competencies developed by the author and proceeded to refine it. Early on, we decided to use a Work Breakdown Structure approach to deriving competencies. First, we defined a set of potential roles that someone in any of the three channels could potentially fill. We termed these 'Macro-Roles' and recognized that more than one could be filled simultaneously. Next, we defined the 'Challenges' that an individual would face in each of these roles. Examining each challenge, we determined what the individual needed to do to address each challenge – these we called 'Micro-Roles' or 'Task-Level Competencies'. For each of these micro-roles we then defined the knowledge, skills and experience that an individual would need to acquire in order to carry them out. Our penultimate step was to create a set of 'Competency Categories' that subsumed these detailed competencies. These competency categories are shown in Table 9.1.

Table 9.1 Clinician health informatics competencies

1. Personal competencies
2. Learning, critical and evaluative thinking, and reading competencies
3. Teaching and supervision competencies
4. Research and concept/methodology development competencies
5. Justification case building (quantitative + qualitative) and evaluation competencies
6. Re-engineering and designing of work and IM processes, (including management of change)
7. Group work competencies: collaboration, team/project leadership, building, management, and participation
8. Technology selection, evaluation, and management competencies
9. General planning, administration, and management competencies
10. Communication, presentation, and publication competencies
11. General computing competencies
12. Health computing competencies
13. General health system-related competencies
14. Information and data collection, architecting, analysis, and management, and distribution competencies

The final step in this process was to identify the importance of each challenge to individuals in each of the macro-roles. This enabled us to give role-specific guidance regarding the importance each competency category has to each role.

The result of this work listed hundreds of detailed competencies. On advice from a colleague (personal communication, Dr. Francis Lau), we created a website that brought all this material together and made it more interesting to read. Furthermore, this website provides a way that an individual can both understand the competencies and interact with them to determine his or her self-assessed capabilities relative to any of the macro-roles. The system also can assist the individual in locating material to upgrade his or her competencies. This system is freely available online [3]. Several articles are also available on this work and its results [4].

Our more recent effort reviewed the Clinician Health Informatics competencies together with recent literature, and determined a set of competencies we perceive all physicians need to have regardless of specialty or professional role. These are outlined in the material that follows.

Choices and Challenges

Although it may not be possible at the start of a medical career to choose decisively in which channel one wishes to function, experience indicates that, eventually, a choice will be made. Without question, the physician-in-training must enter the third channel, and become informatics-enabled. This means that the individual will acquire knowledge about a variety of technologies, about what these technologies can do for healthcare, and about how to make productive use of them. In addition, a number of skills need to be acquired, such as the ability to use programs that support healthcare processes and the ability to interact with a variety of systems. Ideally, these competencies would be acquired in medical school.

Table 9.2 Career paths and requirements

Career channel	Competencies	Minimum credentialing
Research + development HI	Broad discipline of RDHI with depth specialization	Graduate degree in HI
Applied HI/e-Health	Broad discipline of applied HI	Undergraduate/college degree, diploma or other certification in AHI
Informatics-enabled physician	Broad, shallow knowledge and skills in HI	Medical school-based or continuing education in HI

Of course, an individual at some point in his or her career may elect to participate more directly in the deployment and implementation of systems. This is important, as the involvement of physicians and other clinicians in the deployment of systems is essential. However, a great deal more knowledge and additional skill must be acquired in order to participate adequately at this more involved level. These more broad and, sometimes, in-depth competencies can be acquired through a Health Informatics education program, either degree-based or continuing education. Some certification exam programs provide review courses as well [5]. There is also the possible, but challenging, path of self-directed learning complemented by mentorship. Suffice it to say that, for this channel, some degree of formal continuing education will be crucial.

Perhaps the most challenging path is to elect to become a certified or otherwise credentialed Health Informatician, a professional fully competent in Health Informatics and capable of teaching and doing research. Generally speaking, this will require a minimum of a graduate degree and significant experience in actual healthcare situations. In this case, the physician is electing a new or parallel career, the latter expressing both a commitment to medicine itself and to the discipline of health informatics (see Chap. 4 for a description of the clinical informatics medical subspecialty certification program).

These three choices are summarized in Table 9.2.

The Informatics-Enabled Physician

There are many tasks performed by clinicians that can be optimized by informatics tools and methods. It is useful to examine the basic tasks that physicians perform that are amenable to support:

- ***Recordkeeping***: the entry, organization, quality assurance, retrieval and visualization of patient care information.
- ***Information Retrieval***: identifying sources of, searching for, retrieving, organizing and visualizing information from the literature or from sets of patient records, for example, for public health purposes.
- ***Clinical Decision Making***: making decisions related to diagnosis or intervention.

- ***Workflow***: the organization, regularization and optimization of processes for patient care, administration, management, teaching and research.
- ***Planning***: defining and maintaining a focused course of action towards objectives.
- ***Imaging and Image Management***: acquiring, storing, organizing and indexing, processing, visualizing and communicating medical images (e.g., in Diagnostic Radiology, Pathology).
- ***Ordering and Results Reporting***: requesting various health services, for example clinical chemistry or medications, and obtaining results.
- ***Collaboration***: interacting with other members of the care team or with colleagues and students in teaching and research.
- ***Procurement***: defining the requirements for, and participating in, the acquisition of new tools for healthcare. These may include clinical technologies, such as an MRI machine, or computing technologies such as an electronic medical record system for the provider's office.
- ***Communication***: providing information to, or obtaining information from, one's colleagues, patients or service organizations.
- ***Analysis and Visualization***: processing data and information and presenting results in a comprehensible form. This information may relate to patient care, teaching, administration or research.
- ***Learning and Teaching***: acquiring or disseminating new knowledge and skills and/or remaining current.
- ***Business Operations Management***: performing nonclinical tasks to manage and operate a project, department, a practice or an organization.
- ***Assessment and Evaluation***: reviewing results of interventions or experiments.
- ***Research***: seeking new knowledge through investigations (e.g., clinical trials, case reviews or laboratory experiments).

There are many more possibilities, but the list above indicates common tasks, amenable to technological support, which are performed by physicians. It is reasonable to assert that, in today's and tomorrow's world, it will be essential for physicians to able to use supportive technologies in order to make processes, in which they are engaged or for which they have responsibility, more efficient and more effective.

Required Competencies

If these key tasks are to be performed optimally, physicians require a set of competencies (Note that this is not an exhaustive list):

1. **Understanding the technologies that can be applied to clinical practice**, **administration**, **teaching and research**, **as well the cofactors that make this technology effective and the concepts that surround these**. We define cofactors as management of change, adoption support, work process re-engineering, end user education and training, human resources and organizational restructuring and supportive communication. This understanding has sometimes been

called ‘Computer Literacy’, but a better descriptor might be ‘Computer, Applications and Process Literacy’. The technologies include both local and central information systems (including Internet-based systems), the software that they run, and the communications technology that connects them. Topics also include tools: for personal productivity support (e.g., word processing, presentation, spreadsheet, database and the like); for searching for, accessing and integrating medical data, information and knowledge, including -omic, public health and research information; for managing and operating organizations, departments and practices; for clinical data management including images, signals and other data types; for decision support; for care performance evaluation and comparison; for information sharing with colleagues and patients; for accessing evidence; for teaching and research; for operations/workflow improvement and other crucial tasks.

2. **Understanding the value and impacts of systems**. This includes understanding the evidence of the potential qualitative and quantitative effectiveness and efficiency effects of systems, what has worked, critical success factors, and common challenges to the realization of positive impacts.
3. **Understanding the nature of data**, **information and knowledge**. It is necessary to understand the kinds and sources of data and metadata (data describing data), information and knowledge, how they can be retrieved, how they can be organized and processed, how results can be visualized, and how they can be stored for long-term availability.
4. **Comprehending the nature of how decisions are made and the technological mechanisms for assisting humans in making decisions**. This will also include an understanding of the capabilities and limitations of systems that support decision-making, how information to support decisions is represented and stored and how systems provide decision support, as well as an understanding of human cognition and memory and their limitations.
5. **Understanding the nature and capabilities of electronic records systems**. An understanding of how data is captured, how it is organized and indexed, how it is stored, how it is retrieved and how it is presented is central to being an Informatics-Enabled Physician. Typically, one will need to learn about the different types of records systems, the structure of their data storage, vocabularies and data standards, how systems can interact with each other and how we can assure that the meaning of stored information is consistently communicated (via data standards). Because records systems so totally affect practice, topics such as how legislation influences their creation and use (for example privacy law) and how they are affected by ethics, security, etc. are important. This includes the risks and untoward effects associated with such systems.
6. **Understanding the nature of healthcare workflow and how humans and systems interact in a complex and busy environment**. At least a basic understanding of what workflow and workflow reengineering are about and how to improve workflows is very important. Topics include graphic and other representations of workflow, how to detect and correct workflow bottlenecks,

methods for measuring processes, the documentation of context and the integration of data flow, and methods of modifying and restructuring roles.

7. **Seeing how systems can better connect individuals to form teams and support team activities**. This includes the support of the care team's work, as well as mechanisms to communicate better with patients, particularly in long-term care settings. The capabilities of technologies to enable the distributed participation of the members of the care team are important knowledge, as is knowledge related to the creation of efficient inter-person workflows.
8. **Understanding the implementation and use of systems**. Virtually every clinician will be challenged to participate in the acquisition and implementation of systems and be a resource in assuring their adoption. This will require knowledge of the nature of procurement and its processes, particularly new approaches to procurement, as well as of the stages of the system lifecycle from conceptualization, through acquisition installation, implementation, testing, use and evaluation. Related to this area, knowledge of the impacts of systems is fundamental. These include impacts on users and the organization and will address the untoward impacts as well is the positive ones. This is crucial so that failures can be minimized or avoided. Additional topics include basic introductions to: key system types (e.g., for the office, clinic, home), the systems development process (particularly 'Agile' approaches), the challenges of software engineering, the capabilities and limitations of systems, system and information usability, and the diffusion of innovations and system adoption.
9. **Understanding the economics of systems and how to evaluate their impacts**. It will be important to understand how the use of information systems, such as EHRs can affect reimbursement for care. It will also be important to understand concepts related to budgeting for systems, how to measure value, how to assess advisability regarding development and implementation and how to assess the qualitative and quantitative impacts of systems.
10. **Understanding how systems can support learning**. This involves an understanding of how we learn and how systems can support learning processes. Knowledge is needed of techniques that can be used to enhance learning and to make educational systems a part of virtually all of one's activities, from self-learning, to providing patients with learning tools.
11. **Appreciating the context into which systems are introduced**. This includes the importance of understanding organizational culture, fiscal constraints, human resources limitations, organizational and operational challenges, the status of existing systems and users' perceptions of them, previous success and failures, and regulatory and legal issues.
12. **Being aware of key contextual topics**: These include: basic clinical epidemiology; privacy, confidentiality and security; technical and data standards; techniques for managing formal meetings and discussions and achieving consensus; policy development and promulgation; project management, project prioritization and project termination; staff education and training; and the availability and experience with key systems.

Becoming an Informatics-Enabled Physician

Optimally, the competencies identified here would be acquired during basic medical training. Some schools have interpreted this as requiring specific courses in health informatics. Many schools have found that the already crowded curriculum cannot admit yet another course or courses. In fact, it may make more sense for the material to be integrated into existing courses.

The author participated in a Canada Health Infoway [6] Academic/Learning Advisory Group from 2007 to 2009 that surveyed medical school and pharmacy programs in Canada to determine the level of Electronic Health Record (EHR)-related education included in the curricula of Canadian universities. The taskforce found that there was virtually no informatics in the curricula. Among the findings of this group was that the importance of the EHR was not really recognized and accepted, that there was no room in the curriculum for things like the EHR and IT training, that there was a dearth of faculty qualified to teach these subjects, and that there was little research related to them. Recently (2011) the author provided an educational session to the Association of Faculties of Medicine in Canada and it appeared that little progress had been made to that time. Similar results were found by McGowan and colleagues in a survey done with U.S. medical schools [7]. For those deeply involved in health informatics, the failure of medical schools to recognize the need for informatics competencies in their graduates and to implement adequate informatics education and training is frustrating. One conclusion from this work is that medical school faculty require a significant upgrading of informatics awareness and informatics competencies, or the problem will persist. One answer is to pursue the development of 'Informatics-Enabled Physician' continuing education programs.

A more distributed approach – that could be termed 'informatics-embedding' – could be implemented by educating faculty regarding how to introduce the concepts cited here into their syllabi. For example, in teaching anatomy, online systems that provide a virtual cadaver or virtual organs that can be virtually dissected could be used. In Physiology, computer models of cells, organs or body systems, permitting the interactive alteration of parameters, could help the student achieve a deeper understanding of physiological function. In fact, the informatics-embedding approach may be superior and could result in not only medical students but also medical faculty becoming more knowledgeable.

At the present time, we are beset by the reality that little of the material above is formally included in medical curricula, a fact that must be corrected as soon as possible. For those whose training did not incorporate informatics, the solution is either to engage in continuing education programs or in self-directed learning. Two of the most comprehensive continuing education programs in health informatics are the American Medical Informatics Association's (AMIA's) 10×10 program [8] (see also Chap. 8) in the United States or the National Institutes of Health Informatics' Applied Health Informatics Bootcamp in Canada [9].

Of course, self-directed learning is always a possibility, and many resources exist online or can be audited at various schools. Probably the most important amendment to strictly self-directed approaches is to proceed with a mentor, and these are available through the same organizations mentioned above.

The e-Health Team

It is useful to outline briefly the nature and composition of the e-Health team so that the potential for physician involvement is clear. The e-Health Team is the agency in an institution for the realization of the potential of health information technology. The e-Health Team comprises a number of different types of expertise.

Ideally, one or a few individuals fully competent in health informatics provide leadership for the e-Health Team. Other members of the team include those who focus on Health Information Technology (HIT)–individuals who are technology-focused and deeply knowledgeable in matters like procurement, implementation, management and use of systems. The charge of this latter group is to bring systems into operation and assure their use.

Health Information Management (HIM) professionals also provide a significant contribution to the team. Their background in information management and information retrieval makes them important members of the e-Health Team.

There will also be members with either special technology expertise, for example, in system software or networking, or with competencies in areas such as project management or evaluation. Of course, the e-Health Team may engage other types of expertise, such as finance, quality assurance, and workflow professionals, as well as educators and trainers, etc. Perhaps most crucially, though, the e-Health Team needs to include representatives of the disciplines impacted by a system, for example clinicians, technologists and managers.

All members of the e-Health Team must have the knowledge of the healthcare environment, its operations and functions, as well as the technologies and methodologies being implemented. Even the purely technical contributors to the e-Health team need the same types of knowledge required by the Informatics-Enabled Physician. This places a burden on institutions to ensure that all members of their e-Health team are competent in the broad spectrum of informatics at least at a basic level. In other words, the entire team must be informatics-enabled.

Beyond the Informatics-Enabled Physician

Those who elect to delve more deeply and become more directly involved in the informatics domain will, generally, participate in a formal education program. Undergraduate programs leading to a bachelor's degree and graduate programs leading to Masters or PhD degrees in health informatics are available.

It is important to consider the type of career one desires, to obtain advice from an independent source and to select carefully the program one will enter. Different schools have different approaches, and certain programs may not be fully adequate. It would be wise to consider programs that have been created and evaluated by the National Library of Medicine in the United States (see also Chap. 3). Information on advanced programs is available at the AMIA website [10] and at the NIHI website [11]. Proceeding to advanced training can position a person to have an extremely interesting and stimulating career strongly valued by organizations one has the opportunity to serve. Such a career combines the best of clinical practice with one of the most dynamic fields imaginable.

Summary and Conclusions

It should be clear that medical schools have not responded adequately to the emergence of enabling information and communication technologies. Today's and tomorrow's world will expect that physicians are able to not only cope with information and communications systems but also be able to function more productively than has been the case classically. Physicians will be expected to be competent users of information technology, will be expected to consider information systems as an asset for performance management and productivity improvement and will be expected to formulate future practice based on a technological infrastructure.

It should be emphasized, though, that we still need research into required competencies so that the body of competency knowledge is brought and kept up-to-date. Credible individuals taking on this task could be essential to the diffusion of health informatics knowledge into medical practice.

Given the challenges of the dynamic field of healthcare, it will be essential that physicians-in-training acquire an adequate knowledge of systems and their capabilities, learn basic skills to introduce and support efficient use of these systems, and understand in depth how these systems can be integrated into the way they think and they practice.

Ideally, medical schools will respond by incorporating material and experiences that imbue trainees with key knowledge and skills so they can satisfy the expectations of the world they enter. It is arguable as to the best way to incorporate informatics into the medical curriculum. However, it is not arguable as to the importance of doing this.

We are all fortunate that, with time, it has become possible to define generic informatics knowledge and skills, rather than having to train individuals on specific systems. We are now at a point whereby general principles, consensus knowledge and common skills will afford the medical school graduate the basics to function in today's digital economy. Given this, and given the work of leaders who have articulated and continue to refine curricular content, it is quite possible to define the health informatics content that must be melded into all medical curricula and that can be done reasonably painlessly. It does take effort and negotiation, and faculty will have a learning challenge, but undertaking this effort and addressing this challenge will ensure that we have the complement of physicians capable of functioning in the modern world.

Key Take-Away Points

- Many faculty in medical schools are minimally aware of what health informatics and e-Health can deliver to the process of healthcare. It is essential that health informatics be 'marketed' more effectively and that faculty awareness of health informatics be greatly enhanced.
- Medical school curriculum developers must become knowledgeable about the work that has been done to define the informatics competencies required of clinicians in each of the three channels. There is still work to be done, however, on what might, based on evidence, be called an 'absolutely must acquire' set of competencies.
- Medical schools must embrace, and learn from, a sufficient cadre of highly competent informatics educators if the goal is to imbue clinicians with the needed competencies.
- A productive way of creating informatics-enabled professionals is to educate and train medical school faculty in health informatics and have them integrate health informatics knowledge and skills into existing courses.
- Continuing education programs, preferably available via distance learning, are needed to create and maintain an up-to-date complement of informatics-enabled clinicians.

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Chapter 10
Informatics Education for Health Administrators

Margaret F. Schulte

Abstract With the changes in healthcare delivery promoting more effective use of health information technology, it is essential that healthcare administrators have a basic grounding in the best practices for developing and using these technologies in healthcare settings. Educational programs that train health administration students need to incorporate competencies in this area into their curricula. This chapter discusses the informatics competencies needed by healthcare executives and managers and describes how the educational program accrediting agencies are incorporating them into their requirements. To address these competencies, the Association of University Programs in Health Administration commissioned a task force to oversee the development of curriculum modules that can be used by health administration programs in both online and face-to-face settings. In this chapter the curriculum is described and the plans for its dissemination are discussed.

Healthcare executives and managers at all levels of the provider organization interact with health information and information systems on a daily basis. Yet, historically, healthcare has been slow to adopt clinical information systems and, importantly, to adopt information systems that are integrated with one another for the sharing of data and information, for analysis and process improvement, and for accurate billing and revenue enhancement. Lacking an integrated health information technology (IT) presence, health systems are stymied in improving quality of care and patient safety, in reducing costs, in achieving improved efficiencies and in enhancing access to care in their marketplaces, in short, in transforming healthcare.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_10, © Springer-Verlag London 2014

Healthcare delivery in the U.S. is very fragmented, and that fragmentation is mirrored in healthcare information systems. Until recently, healthcare information technology has been reserved for use primarily in the provider's business office to serve billing, collections, inventory, and other administrative functions. Even in these business functions, integration has not been commonplace. In today's healthcare environment, integrated information systems are integral to financial and clinical success, and it is the leadership team of executives, directors, and managers in the healthcare provider organization who must champion implementation and the meaningful use of those information systems. It is their role to think strategically about the investment in healthcare IT and to commit fully and actively to its implementation and use. It follows, that healthcare management education must include program goals and content that prepare students for this aspect of their professional role after graduation. Yet, too many graduates of undergraduate and Masters in Health Administration and related educational programs are unprepared and ill-equipped to assume management and team responsibilities relative to healthcare IT. Over the past decade, many of these programs have increasingly recognized the importance of including health IT, health informatics and health information management in their curricula; however, there has been little guidance and even fewer resources available to respond to this need.

Health IT and the Healthcare Leadership Team

As information technology has begun to proliferate in healthcare, provider organization leadership teams have seen their roles intensify in implementation and use of information systems and subsequently in the use of the data that those systems provide for quality and process improvement, and for strategic decision making. IT is a core part of the infrastructure that the provider organization needs if it is to be a viable entity in the near future, and it is the leadership team who must provide guidance, determination and commitment to organizational change, as well as to overcoming resistance (sometimes overwhelming resistance) and to making the ongoing financial investment that an IT implementation demands. "Given the strong focus on, and significant investment in, the development and implementation of the electronic health record across the U.S., it is critical that those who are in key roles in the provider and vendor organizations understand the complexities and decisional factors related to success in health IT implementation" and use [1]. In short, when health administration graduates move from academia into lower and middle-management roles in provider organizations or when they move upward on the management career ladder, they need to be prepared to be competently involved in IT decision-making, in implementation teams and in information/data management. They need to be prepared to understand the role of top management and to support the strategies within which IT acquisition and implementation decisions are made.

Status of Health IT Education in Healthcare Management Programs

Programs for graduate and undergraduate education for health administration have generally mirrored the development curve that IT implementation has followed in healthcare, where the IT investment and implementation process has been slow. Healthcare is the one sector of the economy that, despite its complexity and its impact on the economy and society, has been, for a variety of reasons, resistant to adoption of IT, particularly clinical systems. Similarly, higher education in healthcare management has lagged in the development of curricula to prepare students for their future responsibilities in IT adoption. Here too, a variety of reasons have been major barriers to curriculum change, not least among them is the lack of resources and expertise to develop and teach health information systems and information management.

However, that scenario is changing. As the Medicare and Medicaid Meaningful Use Incentive programs have been implemented and as patient care reimbursement is increasingly tied to measurable quality improvement outcomes, the provider sector has begun to adopt information technology at a dynamic pace [2]. Thousands of hospitals and medical practices have adopted IT in order to take advantage of the incentive program and to be poised to participate in new methods of reimbursement such as bundled payments. In October of 2012, CMS estimated that nearly 81 % of eligible hospitals were registered in the Meaningful Use program, and almost 20,000 medical practices registered for incentive payments in just the month of September 2012 [3]. The corollary pressure has also intensified in academia to ensure that students in healthcare management are prepared for the changes that are happening in their future employer organizations and for their roles as related to information systems.

Sources for Curricular Content

There are several sources that can be used to identify potential health IT content needed to educate healthcare managers. One source is the accreditation bodies for healthcare management educational programs. Another source is the other organizations who have evaluated what healthcare executives in practice need to do and to know. We will examine both of these sources.

Health IT and Accreditation for Graduate Education in Health Administration

In the early 2000s, requirements for health information systems and management content began to expand in health management curricula at some colleges and universities. These content areas also found their way into accreditation criteria adopted by the Commission for Accreditation of Health Management Education (CAHME) for graduate health administration education. CAHME is the "organization recognized to grant accreditation to individual academic programs offering a professional master's degree in healthcare management education" [4].

While in its more recent transition to competency-based "Accreditation Criteria for 2013 and Beyond", CAHME has shifted from content-specific requirements to identification of competencies that programs match to their mission, there is an expectation that content needed to develop the identified competencies be offered as part of the program's curriculum. In short, accreditation for graduate programs in health administration has evolved over the past decade to reflect the evolution of the healthcare marketplace. In the process of this evolution, CAHME adopted criteria that specifically address IT and the organizational demands of IT management.

In its initial change toward a competency based model in 2008, CAHME rewrote its Self-Study Handbook for Graduate Programs in Healthcare Management Education [5] to delineate at Criterion III.A.2 that "The Program will structure the curriculum so that students achieve levels of competency appropriate to graduate education" (p. 35) [5]. The Handbook provided further detail in describing this as related to curriculum content under "Criterion III.B: Curriculum Content" where it is specified that the "Program curriculum should address the following healthcare management content areas, and is not necessarily course-specific, but rather content that should be taught somewhere in the program" (p. 41) [5]. Under Criterion III.B 19 content areas are outlined and item III.B.7 specifies that "Information systems management and assessment" should be included in the curriculum. The Handbook offers a brief interpretation of the set of 19 content areas by pointing out that "relative emphasis within each of these content areas will vary as a function of the Program's Mission, the core requirements of the school in which the program is housed and the Program's identified set of competencies" (p. 41) [5].

The earlier competency-based model was revised and clarified in the "The Revised Criteria for Accreditation, effective August 2013 and Beyond". Under Criterion III, competencies common to all accredited graduate healthcare management programs are defined under Criterion III.A. Criterion III.A.5, requires that "the program curriculum will develop students' competencies in management and leadership" (p.5) [6]. The new Self Study Handbook offers an interpretation of Criterion III.A.5 by identifying essential management disciplines "as 'core' to the profession of healthcare management" (p. 55) [6]. Here, IT Management is included as one of the competencies that the graduate would possess upon graduation.

The Revised Criteria for Accreditation for 2013 and beyond, in the interest of having programs design their curriculum to fulfill their mission, does not offer more specificity regarding IT management content. It is informative to refer to the earlier

CAHME "Accreditation Criteria Effective May 2009 for Fall 2010 and Beyond" which outlines requirements related to health IT. In the earlier Self-Study Handbook, "Appendix A: III.B. Curriculum Content and Competency Development" contains the CAHME criteria related to information management and assessment. These criteria are outlined below.

III.B.7 Information systems management and assessment INTERPRETATION

Content should normally contribute to students' knowledge, skills, and abilities regarding:

- The historical development of information systems in the health services industry;
- The language and terminology of health services information systems management;
- Techniques and methods to evaluate information systems including forecasting, planning, design, requirements determination, procurement, development, and assessment techniques from an electronic environment perspective;
- Current threats and opportunities, such as privacy and security issues, associated with the management of information systems [7].

The implementation of enterprise-wide information systems has a fundamental impact on the organization, its workflows, its culture, and its opportunity for improvement. Specifically, as related to information systems, the future leader needs to understand the substantive change that an IT implementation implies relative to workflow, internal culture change, and process improvement. The healthcare leader, whether at the top levels of the organization or in middle-management, needs to be able to influence and champion that change. CAHME criteria, as noted above, call for evidence of leadership competencies that will enable the graduate to lead change and impact and influence their organizations in the strategic directions that are supported by information systems. The implementation of healthcare information systems is all about the data and information that these systems make accessible and available for sharing among providers and their patients and for decision-making.

At the undergraduate level, the Association of University Programs in Health Administration (AUPHA) certifies health administration programs. In the most recent criteria, AUPHA, under Criterion 23 requires that the program will provide adequate coverage of all content in a list of 18 content areas. Among these is Information systems management and assessment. This is detailed in the "Guidelines for Undergraduate Certification Criteria, 2012", as content which "explores the critical role information technologies and systems play in healthcare organizations. The focus is often on the underlying technologies including hardware, applications, the Internet, and e-Health; planning and project management and the future of information technology in healthcare management" (p. 8) [8].

These accreditation requirements have been an incentive for programs to enhance their curricula to include information management and information technology competencies and content. However, other elements needed to operationalize the enhancement plans were missing. There was, for example, minimal guidance on what that content should be, and, more fundamentally, there has been a lack of faculty qualified to help guide curriculum development and to teach it.

Health IT, the IOM and the CEO

The literature regarding the relationship between health IT curriculum and healthcare management success outcomes is sparse, dated, and more anecdotal than quantitative. However, in June of 2012, the IOM published a Discussion Paper titled "A CEO Checklist for High-Value Healthcare" that had been prepared by 11 highly respected management and clinical leaders in healthcare. This paper was designed to "inform and stimulate discussion" [9] not to serve as a guideline or research paper. In this paper, the authors drafted ten items that they defined as key to the creation of a high-value healthcare system. Several of these items refer directly to health IT and/or indirectly to the core infrastructure that IT brings to the institution that is focused on creating high-value. Those checklist items related to the use of Health IT call for leadership and organizational commitment to:

- Infrastructure fundamentals:
  - IT best practices – automated, reliable information to and from the point of care
  - Evidence protocols – effective, efficient, and consistent care
- Care delivery protocols
  - Integrated care – right care, right setting, right providers, right teamwork
- Reliability and feedback
  - Embedded safeguards – supports and prompts to reduce injury and infection
  - Internal transparency – visible progress in performance, outcomes, and costs [9]

The items in the checklist are meant to be integrated into the culture of the organization and to serve as core items to transform that organization into a high value enterprise delivering improved quality and reduced costs for patients, payers, and the community. They are the factors that are internal to the organization and that the executive leadership can manage as compared to external forces that cannot be controlled by an organization's leadership, but must be anticipated, assessed and appropriately prepared for. Of the ten items on the checklist, fully half of them are directly related to the implementation and management of IT systems. They emphasize the reasons why it is critical that graduates of masters and undergraduate programs in health administration understand, and gain competency in, the essentials of implementation and management of health IT systems. Next to the physical structures of the hospital or health system, the information system is one of the major investments that the organization will make. Beyond this, it is also the one major investment that will be transformational for the organization. Each of the items in the last four bullet points in the CEO checklist rely on an IT infrastructure that supports the generation of meaningful data to, for example, guide the design and implementation of integrated care, and to support internal transparency and sharing of data and information.

In short, the case is strong for the education of the next generation of healthcare leaders in understanding, analysis, decision-making and application of management principles in health information systems and information management. Graduates of programs in health administration need to know the basics of IT strategy, systems and technology. They also need to understand integration, change management in the IT environment, systems selection and implementation, managing resistance and behavior change, and the ongoing management of the technology. Although healthcare managers also need to know some of the basics of the technology and the design of information systems, the informatics principles they need to know in more depth are those surrounding the selection, implementation and use of the systems as well as the use of the data from them, rather than those that the builders and designers of the systems need to know. However, there is clearly overlap in the content needed by those who manage systems and those who design them.

Health IT and Higher Education – the Opportunity

Graduate and undergraduate programs in health administration are poised to provide the educational experience, and to foster the development of health IT competencies, that their students need to move successfully into leadership and management roles after graduation. Currently, a number of programs across the country include health information management, informatics and/or information systems content in their curricula. However, based on a review in early 2011 of the syllabi of over 30 graduate programs and 15 undergraduate programs in health administration (as part of the HIMSTA project discussed below), the evidence would suggest that there is a great deal of variation in these courses. Some courses focus on informatics, others on information management, others on information technology, and still others teach IT in an array of disciplines and courses such as finance, quality improvement, and project management. Each of these lends itself to a narrow exposure to health IT and, not necessarily, to information and technology management. For example, when IT content is taught in a Finance Course, the content tends to focus on financial systems; when taught in a quality improvement course, the focus tends to be on data and measurement. While each of these is important to the student, a more comprehensive coverage of health IT and information management serves to better prepare the student for management roles in provider organizations.

The HIMSTA Project – or Health Information Management Systems Technology and Analysis

Purpose

This gap in healthcare management education was recognized by the Commission on Accreditation of Health Management Education (CAHME) and by the Association of University Programs in Health Administration (AUPHA) which is a "global network of colleges, universities, faculty, individuals, and organizations dedicated to the improvement of healthcare delivery through excellence in healthcare management and education" [10]. In a collaborative arrangement, CAHME and AUPHA joined forces to develop a plan to address the gap and to support healthcare management education programs in their health IT curriculum offerings. The plan was successfully presented to the Health Information and Management Systems Society (HIMSS), and subsequently AUPHA was given a 3-year grant to fund the development of a health IT and information management curriculum that would be made available to programs throughout the country at no cost to them.

The project was titled the Health Information Management Systems and Technology Analysis (HIMSTA) project and was "designed to develop an educational infrastructure, method and cadre of teachers who can prepare academic program graduates to address the current and future healthcare information management and technology challenges" [1]. The plan for implementing this initiative included the development of:

1. A model curriculum for use in undergraduate and graduate healthcare management programs. At the core of this model would be a set of competencies crafted to serve as the "guiding framework for the design and development of the HIMSTA curriculum" [1].
2. Course module development
3. Train-the-trainer program to prepare instructors to teach the curriculum
4. Future research agenda
5. Program assessment and evaluation

Process

In order to accomplish this, top health IT educators from across the country came together to volunteer their expertise to develop the curriculum and to guide its development. After drafting knowledge domains and related competencies, course content was outlined in a modular approach. These modules were intended to provide a basic curriculum and would also be able to be used as a complete course or in segments to supplement classroom courses. Before finalization, this outline was sent to all AUPHA member program directors for feedback and input.

The outcome of this process, was a curriculum organized around eight knowledge domains, content for which would be delivered in 14 modules. These were designed for use in online or face-to-face class delivery. Table 10.1 offers an outline of the knowledge domains, competency statements, and modules that comprise the HIMSTA curriculum.

Each module was subsequently prepared by faculty from colleges and universities throughout the country who were selected in a call-for-proposal process. Once drafted, the modules were reviewed by the HIMSTA Task Force and then finalized by the faculty developers. Each of the modules contains course content delivered in multiple mini-lectures of 15–20 min, an instructor's manual, a syllabus, suggested

Table 10.1 HIMSTA curriculum modules

Knowledge domain	Competency statements	Modules
1. Information management	1.A. Understand the major features of the information revolution; the role of knowledge workers; the differences between data, information and knowledge; data analysis and reporting; and major trends in IT; particularly as they relate to HIT.	1.a. Introduction 1.b. Data and information
2. Strategy and planning	2.A. Develop and align information systems strategy and plan with the organizational strategy and plan to support the achievement of organizational goals.	2.a: Strategy formulation 2.b: IS planning and alignment
3. Assessment, system selection and implementation	3.A Understand the purpose, use, and key functions of various administrative and clinical information systems and the factors that may influence adoption.	3.a: Purpose, adoption, and use of healthcare information systems
	3.B. Design and plan for the selection and acquisition of a new or upgraded healthcare information system.	3.b: Organizational commitment
	3.C. Appreciate the necessary resources, processes and support needed to effectively manage the implementation of healthcare information systems projects.	3.c: Selection
	3.D. Demonstrate ability to apply project management principles, tools, and techniques to health information technology implementation.	3.d: Implementation
4. Management of information systems and resources	4.A. Manage information systems assets and functions to reach organizational goals. 4.B. Promote and manage the change that is necessary to reach the organization's information systems goals.	4.a: Change management 4.b: Management of IS function
5. Assessing emerging technologies	5.A. Explore innovative uses of existing and emerging technologies to optimize healthcare delivery and improve efficiency.	5.a: Innovative uses of technology
6. Assessment of the value of IT	6.A. Establish measurable goals and objectives, and assess the extent to which a health information technology implementation achieved those goals and objectives	6.a: Assessment of impact of IS on the organization
7. Security and privacy	7.A. Demonstrate knowledge of legal and ethical issues and principles for protecting patient privacy and the security of health data.	7.a: Security and privacy
	7. B. Assess and implement policies related to the security of systems to protect data integrity, validity, and privacy.	
8. Systems and standards	8.A. Understand the role of standards and protocols in health information technology, the principle systems of protocols applicable to HIT and the policies and development bodies responsible for HIT standards	8.a: Information systems
	8.B. Assess the core elements of information systems and their networks in order to effectively manage both the systems and data assets.	8.b: Standards

readings, weblinks and assignments, and discussion and assessment questions. The module developers had the opportunity to add other teaching tools, and consequently some of the modules include case studies, videos, optional readings, and exercises. As of this writing the curriculum is in the beta test phase in over a dozen programs, and following feedback and needed revisions in the Spring/Summer of 2013, the curriculum will be made available for all graduate and undergraduate programs that will find it of value in their course offerings.

Next Steps

It is not sufficient to provide a curriculum. Competent teaching skills are needed to effectively deliver that curriculum and work with students to build their competencies. In a second phase of the HIMSTA project, a train-the-trainer program will be offered to instructors who wish to teach health information management and technology and who are already assigned to related courses.

In this rapidly evolving field of health IT, updates will be required to keep the HIMSTA curriculum relevant. Consequently, the program's effectiveness will be assessed from time to time. With input from programs who adopt the curriculum and from faculty who actively use the content, the knowledge domains, the competencies, and the course content will also be re-visited from time to time. Finally, once the curriculum is initially finalized, it will be modified for appropriate use at the undergraduate level.

The HIMSTA curriculum was designed and developed to assist healthcare administration programs in meeting their accreditation requirements; to prepare students for the roles that they will assume in healthcare management. It is for each program to determine, based on its mission, what will be offered in its curriculum. The HIMSTA curriculum offers one resource that will support those decisions relative to health IT and information management education.

Summary

Over the next decade, healthcare IT will continue to grow and demand funding dollars, but, more importantly, it will provide the data and information that healthcare providers need to improve care delivery processes, develop the kinds of quality improvement programs that will advance patient safety and ensure that better results are delivered for the dollars spent, and improve financial performance. Unlike other investments in technology in provider organizations, information technology and the electronic health record will be ubiquitous throughout the delivery system. IT will impact the way in which medicine is practiced, the ways in which medical teams work together, and the role of the patient in his/her own care. It will provide the information that is essential to drive improved quality, greater efficiency and better access to care. In short, it will support the much-needed transformation of healthcare delivery in the U.S.

However, IT is only one "cog in the wheel" of this transformation. It is the element that makes the transformation possible if managers and leaders have the competence and will to make strategic decisions regarding IT deployment, bring a sustainable vision and commitment to the process and make effective long and short term decisions that overcome barriers and require the use of the technology. Educational programs in health administration are the foundation on which that knowledge and those competencies are developed and through which the incoming generation of leaders are prepared for their role. It is important that faculty have the tools they need to teach the essentials of health information management and systems in order to prepare students for that role. The library of materials for this purpose is growing daily, and the HIMSTA curriculum can provide the framework and a host of teaching tools to use those materials in a meaningful and effective curriculum.

Key Take-Away Points

- Health information systems infrastructure is key to the successful transformation of healthcare delivery and to the strategies that health IT leaders pursue to achieve this transformation.
- Health IT and information management comprise an important competency for graduates of healthcare administration programs.
- Health IT curriculum teaching resources are being made available to undergraduate and graduate programs in health administration.

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Chapter 11
Bioinformatics for Biological Researchers—Using Online Modalities

Chiquito J. Crasto

Abstract We present here a paradigm for online bioinformatics education, geared primarily towards bioinformatics applications, and currently tested in a graduate level bioinformatics course. This course is targeted to students and researchers whose primary research and education interests are experimental and who need bioinformatics to supplement their knowledge base and aid their research endeavors. We discuss the types of bioinformatics course content, materials and tools that biological and other science graduate students need and focus on methods for presenting this content in an online mode. Two methods of presentations are discussed: (1) video-captures of the demonstrations of bioinformatics web or standalone applications are edited to highlight salient aspects of the resources; (2) presentations that synchronize the videos of the lectures with the accompanying slide-shows. The aim of this type of education is to help users not only within the educational context but also to supplement their research. The psycho-ergonomic factors associated with such content creation as well as usage are also discussed.

What Is Bioinformatics?

The domain of bioinformatics arose from necessity: the need was recognized following the publication of the first draft of the human genome. It was inevitable then that conventional methodologies would be supplanted by computational strategies to process and extract results from the increasingly overwhelming amounts of data being generated. Figure 11.1 shows the N-gram viewer developed by researchers

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_11,

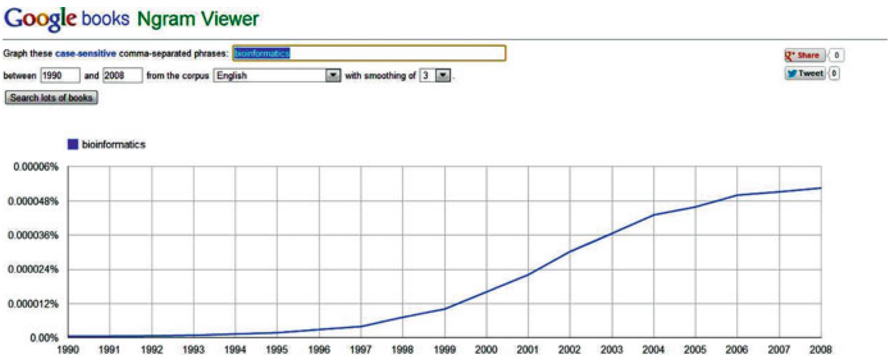

Fig. 11.1 A graph of the results of the search in Google's N-gram viewer for the word "bioinformatics." Results are available up to 2008 (Google and the Google logo are registered trademarks of Google Inc., used with permission; Screen capture is courtesy, MWSnap (http://www.mirekw.com/winfreeware/mwsnap.html))

at Google, Inc [1]. The N-gram viewer is the result of indexing the text of several million books already in print, into words and concepts. A search of the term "bioinformatics" in the N-gram viewer indicates that the first references to the term "bioinformatics" started appearing in the text of books around the middle of the 1990s. The largest relative increases were seen between 2000 and 2001, perhaps, following the publication of the human genome. Another large increase in this word's usage can be observed between 2002 and 2003. Records for the N-gram viewer are only as recent as 2008. The use of the term "bioinformatics" in books has, after 2005, seen modest increases, and some decreases, from year to year. This is not necessarily because of a decrease in the use for bioinformatics (and consequently, the need to publish the word) in the realm of bio-medicine, but that the term has moved on from the domain of published books to that of the literature of journal articles in informatics, mathematics, computational science and biomedicine.

Figure 11.2 shows the results of searching the biomedical literature through PubMed using the search term "bioinformatics." The increase in the publication of journal articles related to bioinformatics has been steady. Prior to 2000, *in toto* roughly 3,000 articles associated with bioinformatics were published in the 1990s.

Indeed, in the approximately 15 years since bioinformatics has increasingly become part of the biomedical parlance, the correspondingly increasing use of computational and information sciences to address biological problems is reflected in the biomedical literature. The Microsoft.com web resource reports that there are 43 highly rated journals either dedicated to bioinformatics, or that widely publish papers in bioinformatics [2]. The Nucleic Acids Research journal that has traditionally published mainstream, experimental, research articles now dedicates two separate issues to bioinformatics related topics [3]: the database issue and the web-services issue. The articles in these issues are related to descriptions of computational tools for information retrieval, storage and dissemination of biomedical knowledge, accessible via an Internet browser.

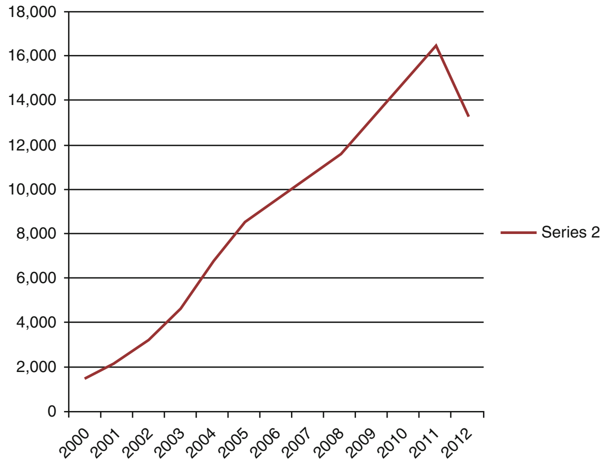

Fig. 11.2 The figure represents the number of articles that result from a search of the word "bioinformatics" between years 2000 and 2012. The graph was generated using Microsoft Excel (Screen capture is courtesy, MWSnap (http://www.mirekw.com/winfreeware/mwsnap.html))

The definitions of bioinformatics vary. According to the National Center for Biotechnology Information (NCBI), "Bioinformatics is the field of science in which biology, computer science, and information technology merge into a single discipline. There are three important sub-disciplines within bioinformatics: the development of new algorithms and statistics with which to assess relationships among members of large data sets; the analysis and interpretation of various types of data including nucleotide and amino acid sequences, protein domains, and protein structures; and the development and implementation of tools that enable efficient access and management of different types of information" [4]. The NCBI definition, as its length suggests, attempts to be all-encompassing. Luscombe et al., summarize their also broad definition more succinctly as "… bioinformatics is a management information system for molecular biology and has many practical applications" [5]. Richard Durbin, Head of Informatics at the Wellcome Trust Sanger Institute [6] narrows the definition to "… management and the subsequent use of biological information, particularly genetic information." The Bioinformatics Resource Portal lists several definitions that are variations on the same theme, with varying and sometimes interchangeable definitions of bioinformatics and computational biology [6]. Though bioinformatics evolved from a need to use computer and information science to address biological (and increasingly, biomedical, and clinical) challenges, one must also allow that bioinformatics can be a vehicle for independent discovery.

Particularly relevant to this chapter is another definition—an opinion presented at the Bioinformatics Resource Portal that relates to the practitioners of bioinformatics. The authors of this resource raise the question, "What is the difference between a bioinformaticist and a bioinformatician?" The answer they provide can be paraphrased as: a bioinformaticist is a scientist that is intrinsically involved in the developmental aspects of bioinformatics. This includes software (and database) development. A bioinformatician on the other hand is a scientist who does not delve into the developmental or discovery aspect of the science, but is an effective (preferably a power-user)

user of bioinformatics-related tools. Others use these terms interchangeably. The distinction, therefore, is not likely to be universally accepted.

This chapter on bioinformatics education focuses on disseminating knowledge to those who use bioinformatics tools, not to educate the tool developers. For clarity, the term that will be used is the bioinformatics end-user (as opposed to the bioinformatics developer), with the hope that the recipient of the education will evolve into a bioinformatics power-user.

Bioinformatics Education

As the role of bioinformatics in the biosciences has become more prevalent, the need for bioinformatics specialists has correspondingly increased. This has given rise to the need for identifying education modalities geared towards the creation and development of bioinformatics practitioners. Those involved in the developmental aspects of bioinformatics typically have backgrounds in mathematics, the physical and information sciences, and have enhanced their educational and research repertoires by delving into and acquiring knowledge in the biomedical sciences. Instances of biomedical (experimental) specialists acquiring mathematical and computational skills, useful in algorithm development, are relatively fewer.

Once the needs for processing biomedical knowledge efficaciously and rapidly were articulated, it became increasingly clear that it would be necessary to train bioinformatics specialists through coursework that would combine all the necessary skills to achieve competence in bioinformatics—as end-users as well as developers.

The need for bioinformatics education was expressed early on in the WEB series of conferences—Workshop on Education in Bioinformatics [7]. The first such meeting was held in 2001, and it has continued yearly. One of the salient conclusions from these meetings, expressed by Dr. Shobha Ranganathan, was the need to recognize that a one-size fits all approach for bioinformatics education was not necessarily optimal. Self-learning, according to Dr. Ranganathan, was one of the keys to success—given the potential scope and range of areas in which bioinformatics methodologies might be applicable.

Developing a bioinformatics curriculum poses a greater challenge than other domain-specific curricula, because of the range of applications than can challenge a budding bioinformatics practitioner. An undergraduate curriculum would necessarily have to combine coursework that allows the recipient of the education to attain competence and expertise in the developmental as well as user (power- and super-) aspects of bioinformatics.

The Universities.com web resource, a meta-compendium that, as of 2012, stores information related to close to 5,000 online degrees and about 150,000 campus degrees, reports that 41 universities in the United States have on-campus bachelor's degree programs in bioinformatics [8]. A search of this resource identifies only one university, Walden University, which has an online Bachelor's degree in Public Health Informatics. Forty-seven U.S. universities offer a Master's and/or a Ph.D.

degree in bioinformatics. Of the two lists (graduate and postgraduate curricula in bioinformatics), only five universities offer both: George Washington University, Rochester Institute of Technology, University of California at San Diego, University of the Sciences in Philadelphia and Virginia Commonwealth University. Three top-tier universities that offer a postgraduate degree in Bioinformatics (or a closely related field), The Massachusetts Institute of Technology, Columbia and Yale universities, do not offer bachelor's degrees.

Online Education

The advent of, and the advances in, the development of online technology have caused a paradigm shift in today's culture (see also Chap. 2). The facility with which online resources can be accessed and utilized has given rise to previously unknown terms such as online shopping, telemedicine, and, in the context of this chapter—distance education and e-learning. Distance education offers the convenience of education, especially for older students, working students and returning students. Distance education is often tailored to achieve specific job-oriented goals—learning a specific skill. Because of the scalable nature of the system and a potentially enormous student body, not counting starting costs and those for technological infrastructure, distance learning can be made more affordable.

In the last decade, there has been a plethora of universities that offer online education exclusively; or, established physical campus-based universities offer parallel online tracks to on-campus courses. The quality of some of the online institutions is often suspect; these are often disparaged as being mere degree mills. Most online or e-learning entities have to seek and attain accreditation. As of the end of 2012, the e-learners.com web resource listed 171 e-learning institutions, more than half of which are online tracks of campus-based universities.

There has been a concerted effort to make high level coursework available online, and, more importantly, free. This marks a paradigm shift in traditionally held views of education. This section describes several examples of what are known as Massive Open Online Courses [9] more commonly abbreviated as MOOCs. The term MOOC was coined by David Cormier and Bryan Alexander [10]. MOOCs find their origins in what were and continue to be called correspondence courses. The fundamental notion on which MOOCs are founded is that education through online modalities can be available free and with unrestricted enrollment. While the expertise in establishing MOOCs often arises from academia, they are not restricted to a university. Conceptually, enrollment or registration is not required and student-evaluation metrics may or may not be in place. Depending on which entity creates the course, certificates of successful completion might be issued. Because of the unrestricted nature of participation, MOOCs, depending on technical facilities, can be scaled to accommodate interested participants from around the world.

In some well-advertised cases, materials, including course syllabi and tests were made available online at the discretion of the faculty teaching the course, with the compliance and commitment of the administrations of the universities. MIT, in 2002, introduced the Open Course Ware project [11]. The University of California at Berkeley has made audio and videos of some of its courses available online, through the WebCast project [12]. Stanford and Yale also have similar efforts ongoing. More recently, Harvard University and MIT have invested vast financial resources in the creation of an online learning program, edX [13]. MITx was the not-for-profit component of its online, free education efforts [14].

Commercial and not-for-profit entities have also made efforts towards producing educational content and making it available online. These include, YouTube Edu [15] (currently owned by Google) and Apple's ITunes U [16].

The Saylor Foundation is a non-profit entity that serves as a meta-resource for free online education [17]. The Saylor Foundation organizes courses available online into a curriculum that very easily mirrors course curricula required to attain an undergraduate degree; 273 courses are currently offered. For example, a Biology curriculum has available 12 core courses that range from Introduction to Molecular and Cellular Biology (including a laboratory component) to Introduction to Electromagnetism. In addition, 22 electives are also available. Since each course is developed from potentially disparate sources (when available), a symbol beside each course indicates how complete the course is, whether it is "in development", whether it is being considered but not yet developed, and even if the course has a final examination. On completion of the course, the foundation awards the attendee with a certificate of completion.

A similar online educational entity, originally developed by Stanford University faculty, is Coursera [18]. This web resource makes individual courses available free to users. Unlike, the courses at the Saylor Foundation, Coursera courses are not collated into curricula, but exist independently. Courses in 21 different widely dispersed categories are available. To take a course in Coursera, registration is required. Most courses run for a few weeks. While Coursera was originally a partnership of Stanford, Princeton, the University of Pennsylvania and the University of Michigan, it has expanded to include faculty from additional universities.

From a bioinformatics standpoint, the Biology and Life Sciences section of Coursera consists of courses that could be mainstays of a bioinformatics curriculum. These include Computational Neuroscience (though narrow in scope), Genes and the Human Condition, Useful Genetics, Network Analysis in Systems Biology, and Dynamical Modeling Methods for Systems Biology. In the category on Statistics, Data Analysis and Scientific Computing, the Mathematical Biostatistics Boot Camp, Neural Network, Scientific Computing, Data Management for Clinical Research and Network Analysis in Systems Biology, are courses in which a student who wishes to develop skills in the developmental aspects of Bioinformatics might evince an interest.

The revelation as far as online education is concerned occurred with the creation (and the increasing use of) the Khan academy [19]. The philosophy behind this novel educational paradigm is that instances of knowledge can be disseminated to learners in short, easily accessible, segments—leveraging novel teaching perspectives. The Khan Academy web resource claims more than 3,600 videos in different aspects of education, but mainly focuses on K-12 education. The presentations range from mathematics to preparation for standardized tests—both in the United States and in select countries abroad. Each video is of less than 10 min duration. Each video is focused on very specific topics. Additionally, web-based presentations allow the students to dynamically interact with the material being presented, verify answers and access explanations to the questions (and solutions) within the same webpage.

The technical (hardware) infrastructure is available to make bioinformatics education online—whether free-of-charge or through a fee-based vehicle.

Online Bioinformatics Education

David B. Searls, an independent consultant and adjunct faculty at the University of Pennsylvania School of Medicine, believes that a potential online bioinformatics curriculum would require the following courses [20]: Fundamentals of Biology, Principles of Evolution, Ecology and Behavior, Biochemistry, Genetics, Molecular Biology, Cell and Systems Biology, Eukaryotic Gene Expression, Computational Molecular Biology, Introduction to Genome Science, Genome Analysis, Biological Seminars, Differential Equations, Numerical Methods, Linear Algebra, Statistics, Probability, Automata, Discrete Math, Analytic Combinatorics, Networks, Applied Optimization, Dynamical Systems and Chaos, Information theory, Signals and Systems, Introduction to Computer Science and Programming, The Structure and Interpretation of Computer Programs, Data Structures, Machine Structures, Building Dynamic Websites, Software Engineering, Introduction to Databases, Computer Graphics, Digital Image Processing, Massively Parallel Computing, Introduction to Algorithms, Computational Biology, Artificial Intelligence, Learning Systems, Natural Language Processing, Computational Seminars, Organic Chemistry, Pharmacology, Biomedical Engineering, Game Theory, Entrepreneurship and Justice. This course is a hypothetical curriculum, which would be clearly impractical for any student to get through reasonably. Dr. Searls believes that these are the educational requirements that would be necessary to "create" a bioinformatics practitioner. This list of courses was culled from courses that are freely available and consisting of video-based lectures.

Merely perusing through the course listing of Dr. Searls' recommendation carries with it several lessons on the future of bioinformatics education. While this is an extensive and comprehensive list, the breadth of the topics covered illustrates the nature of bioinformatics—that it cannot be constrained into a restricted curriculum. A bioinformatics researcher can be called on to address any of the issues covered by this extensive list of courses. Indeed, one cannot claim to be a bioinformatics specialist based purely on taking courses in a small sub-set of the courses listed above. To return to Dr. Ranganathan's opinion: "self-learning" is essential [7]. The amount of learning depends on the nature and the scope of the biological problem to be solved.

Though this is just one opinion as to what constitutes the knowledge required to gain a comprehensive understanding of bioinformatics, it does identify the scope of domains with which a bioinformatics developer or even a power-user could be called to contribute. Dr. Searls does differentiate the course work into different tracks—biology, computer science, etc. Given the range, depth and number of recommended courses, a curriculum composed of all these courses is not practicable. Still, it is conceivable that a dedicated and standout individual can conceivably successfully complete all of these courses, especially, since they are accessible at no cost. Each of the above described courses is taught by a panel of faculty from different universities mostly within the United States, but also from abroad.

The Johns Hopkins University online bioinformatics program leading to a Master's degree consists of 11 courses: five core courses (molecular biology, gene organization and expression, foundations of algorithms, principles of database systems and introduction to bioinformatics), four out of 17 concentration classes, one elective (out of 12) computer science courses and one elective (out of 16) courses in biotechnology, with a thesis option. The University of Illinois at Chicago has a bioinformatics certificate program that requires students to take a required course in "Introduction to Bioinformatics" and two out of seven electives. For the masters' program, nine courses are required, seven out of eight courses and additionally, two courses in engineering law and engineering management are required. The Master's Program in Bioinformatics, only offered online, at Brandeis University includes four pre-requirements, six required courses and three electives in category A (Applications) and three in category B (Development, programming, etc.) The comprehensive set of courses available as described by Dr. Searls [20] and the above examples should suffice to present a notion of what might be in an online bioinformatics postgraduate curriculum. Other universities also have online bioinformatics curricula, but the specific nature of the coursework are variations on those mentioned earlier in this paragraph.

A 2012 search among the Saylor Foundation's web-search results for the word "bioinformatics" returned 23 web pages. While a bioinformatics curriculum does not currently exist at the Saylor Foundation, bioinformatics topics are discussed as sub-topics of other courses.

The salient point to note here is that the development of a curriculum in bioinformatics does not require the creation of a new discipline—e.g., chemistry. Coursework from other established disciplines can be incorporated into a bioinformatics curriculum.

The S* (S-Star) alliance of eight universities: University of Sydney in Australia; Karolinska Institute and University of Uppsala, in Sweden; National University of Singapore in Asia; South Africa National Bioinformatics Institute, University of the Western Cape, South Africa, and Stanford University, and (more recently) the University of California San Diego (USCD), aimed to make good bioinformatics education available freely to participants, worldwide. This alliance sought to provide "global bioinformatics" education through dissemination of online (with video and e-learning modes) modules of bioinformatics and genomics.

The resources were hosted at the National University of Singapore. Because of infrastructural concerns, there was a limit of 100 participants every year. This number was exceeded every year. Typically, 150 participants registered. Of these, about two-thirds completed the required material and about half successfully completed the coursework. One of the features of the S-Star project was the use of online presentations that used content consisting of lecture-videos synchronized with slide presentations. A paper detailing the successes of the S* program was published in 2003 [21].

Comparison of Online and In-Person Bioinformatics Educational Programs

While there have been no evaluative studies that compare online versus in-class bioinformatics education, there have been several studies that evaluated online versus in-class education in general. The overall consensus, including a paper from the Sloan Consortium [22] is that there are no significant differences between student performance and interest in the course [23]. The metrics used to test were test-scores and student satisfaction. In some cases, online students had to be incentivized to respond to evaluation surveys [24, 25]. Berner and Adams reported that streaming video added to a slide presentation was not preferred to slide presentations with embedded audio [26].

While the overall consensus is that using the typical evaluation metrics, in-class courses are not significantly advantageous, the overwhelming consensus is that educators and administrators believe that online education represents a growing part of the future of education, for the reasons discussed previously.

Online Bioinformatics at the University of Alabama at Birmingham (UAB)

At UAB we have begun to add online education to a month-long bioinformatics course for Genetics graduate students. The author's bioinformatics educational efforts arise from his role as the course-master of the bioinformatics course. This month-long course module, though originating within the Department of Genetics, comes under the overall umbrella of the Graduate Biomedical Sciences (GBS) curriculum.

The GBS system consists of the themes of: Biochemistry & Structural Biology, Cancer Biology, Cell, Molecular & Developmental Biology, Genetics & Genomic Sciences, Immunology, Microbiology, Neuroscience and Pathobiology & Molecular Medicine [27]. The GBS system was created to encourage interdisciplinary, collaborative research and allow graduate students the flexibility in pursuing postgraduate studies. For example, a graduate student from the Department of Genetics can pursue research with a faculty from any of the other themes. Students typically undergo training in a few core courses before embarking on a series of electives that will help them attain specialized training in keeping with their research endeavors. The interdisciplinary nature of the GBS construct allows students a choice of more than 350 faculty members with whom to pursue research.

The Bioinformatics course module that is currently being taught is mostly designed to be an applications-based program targeted to the end-user of bioinformatics or *biological researchers*. Recent experience has revealed that an overwhelming majority of students (and those pursuing a doctoral degree under the GBS umbrella) that have taken the course have expressed an interest, and, subsequently gone on to pursue research with a strong experimental emphasis. Bioinformatics is undoubtedly here to stay and its role in the biosciences, as has been illustrated previously in this chapter, will be ever increasing. It will also be ubiquitously integral to bench biology researchers everywhere. It is incumbent therefore on all biomedical scientists to be well versed with most bioinformatics resources, develop expertise in the use of the more popular and comprehensive resources such as the NCBI portal (often used synonymously with Genbank) and the EXPASY (formerly SwissProt), to name but two of many, as well as achieve an aptitude and facility of use of bioinformatics resources that are less well known, but which will help a researcher address specific issues relevant to his or her research.

The author's experience in teaching the bioinformatics and proteomics courses is that the knowledge of even senior graduate students as to available resources that will aid their research efforts is rudimentary at best. The lack of the knowledge of, and how to use, these resources results in an overt (and most often, unnecessary) reliance on bioinformatics specialists for assistance. Most of the web resources are relatively user-friendly and do not require input from a bioinformatics specialist. The resources are described in the database and web resources specialized issues of the Nucleic Acid Research journals, as well as a plethora of bioinformatics journals that are currently available, in print, and exclusively as e-journals. The emphasis of the bioinformatics module is to convert end-users into power-users.

Overview of the Curriculum

The curriculum of this module and the topics covered, other than the mainstays in bioinformatics, e.g., (nucleotide) sequence-based bioinformatics, reflect the expertise at UAB, which is considerable and comprehensive. Additionally, the topics covered are: Genomics and Bioinformatics, Proteomics Bioinformatics, Bioinformatics of Microarray Analysis, Introduction to Statistical Genetics, Molecular Dynamics, Data and Text-mining of the biomedical literature and biomedical resources, Bioinformatics and Disease, Plant Bioinformatics, Microbial Bioinformatics, Algorithm Development for the Biosciences and Bioinformatics Workflows, Introduction to Clinical Bioinformatics, and Ontologies and Taxonomies.

The online structure of this class (as a support for in-class lectures) lends itself to an evolving system of education. As faculty and their expertise are integrated into the module (often based on availability to teach), the curriculum is likely to change. The online modality that will be elaborated in subsequent paragraphs will ensure that students are not likely to suffer because of faculty availability. Students will be able to access lectures available online that are not being taught, either for the class or for their own knowledge.

In the bioinformatics course module, in addition to mid-term and final examinations, every student is required to identify a resource from the latest web-resources issue of Nucleic Acids Research—one that is not discussed in the class. The student learns how to use the resource and presents it to the class as a combination of a slide presentation that describes the resource and the underlying science, as well as a live-demonstration of the resource. This 15 min presentation is then evaluated on the basis of preparedness of the student to discuss the science, the quality of the slides, and the facility with which the student has gained experience in accessing and using the resource. Audience participation also receives credit.

Online Methodology

The online presentations supplement the in-class curriculum. The software and the equipment are purchased through UAB. The content is created and presented by the author (as course master) and the lecturers for the courses. All the demonstrations and "walk-throughs" of the resources are carried out by the course master and the faculty members teaching the lectures in the course—based on material that is publicly accessible.

Since 2009, the author, who has been the course master for the GBS Bioinformatics module, has captured videos of the lecturers. The raw videos of the lectures have been made available to the students. Whenever videos and slide presentations of lectures were available, the lecture video and slides were synchronized and uploaded as an online presentation of the videos. The author used the PresenterSoft software to accomplish this [28]. This software allows the uploading of the video in one "window" and the slide presentation in the other "window." In this second window, other modes of presentation can also be uploaded, such as flash videos. The latter is particularly useful if a split-screen presentation is desired where one shows the lecturer and the other shows a flash video of the demonstration of a web resource or of the use of particular software, etc. Figure 11.3 illustrates a presentation that includes video (of the author) delivering the first lecture of the Bioinformatics module. The video is synchronized with a slide presentation on the right hand side of the figure. On the bottom left hand are the titles of the slides. A student clicking on the slide will automatically be taken to the presentation at the point in the lecture where the lecturer is depicting and describing the contents of the slide.

PresenterSoft, the end-user version, is relatively inexpensive and easy to use. One of the disadvantages is that the final product is rendered as a link that will only

Fig. 11.3 Video of online lecture

work using Internet Explorer browsers. The online presentation cannot be viewed in other browsers such as Google Chrome, Mozilla Firefox or Apple's Safari. There are however, other (albeit, more expensive) products which can be used for split screen presentations, including one from Adobe, Captivate [29].

The process for creating the online presentation is relatively simple. After uploading the video in one "window" and the, e.g., slide presentation in the other, the video is run. As the video runs, a mouse-click feature allows the creator of the presentation to click each slide when the video refers to that slide. In these presentations, the user can click on the link for a specific slide while the presentation is being viewed, which takes the presentation directly to the video associated with the slide. A select number of split-screen, video-slide presentations are made available to the students for knowledge reinforcement—after they have attended a lecture. These are available as links through UAB's Blackboard system for the class (officially, GBS722).

UAB's GBS bioinformatics course module is designed especially for end-users, for students who are likely to be interested in learning how to access and use bioinformatics resources, as has been mentioned here previously. In order to make content available online, it is necessary to perform screen-captures of live demonstrations of the use of the web-resources. The screen captures are then stored as typical movie formats, avi, mpeg, etc. Several such screen-capture software systems are available, but very few are free. The free software often allows limited use: for a few days after which paid registration is required, or it leaves a water-mark on the rendered movie, which obscures key aspects of the demonstration.

We used Camtasia software for screen-capture [30]. Once the screen capture has been rendered into a Camtasia-formatted file, the software has features that allow the movie to be edited while it is being replayed, before the final movie is rendered. These features include panning across or zooming in and out of the screen captured movie to highlight certain parts of what is visible in the movie. A mouse-driven highlighting tool can also differently color parts of the capture that the content-creator wishes to highlight. Camtasia has a voice recording feature that allows the content-creator to add a voice-over commentary to the video-capture. The final step is the rendering of this completed file into the final movie that contains all the highlights and edits performed in Camtasia.

One of the lectures in the GBS bioinformatics module and a guest-lecture in another course, taught by the author, is a lecture on the use of proteomics online resources. The author has used Camtasia to create screen-captured and edited movies for more than ten of the most frequently used proteomics resources. One example is the use of the Protein Data Bank (PDB). The author screen captured a demonstration of the prominent features of PDB: how to use the resource's search system, how to access the PDB entry for a protein, how to process a PDB file for a protein, how to visualize and manipulate the view of the structure of a protein or other macromolecule within the browser, using online JAVA-based software. The resulting video with embedded voice-over is less than 15 min. This video provides an overview, with some details that will enable most students with some experience of proteins to navigate through the resources as well as understand some aspects of macromolecular crystallography. Currently available movies associated with proteomics-bioinformatics are: how to use a FASTA-formatted file, how to use software to create small molecules and peptides, how to perform computational protein-ligand docking, how to use the EXPASY (SwissProt) web resource, presentations on protein folding, homology modeling, hydropathicity of alpha helices, molecular dynamics, how to use secondary structure prediction web-software, how to use RASMOL-a macromolecular visualization program, a presentation about threading, and how to use the wwwpdb—a meta resource for macromolecular crystallography.

The Approach

The eventual aim of the GBS bioinformatics course is to ensure an applications-based bioinformatics education to students. Additionally, we also believe that these presentations will help these students and researchers to support their primary experimental biomedical research endeavors. Short-term, this would be useful for the students while the course is on-going. The long-term goal however, is to ensure that students can access specific presentations, whenever required. UAB's Center for Teaching and Learning [31] and the author are working together to convert each full lecture into a "story-board" consisting of smaller modules, each sub-topic, an independent screen captured (and Camtasia-edited, whenever necessary) video or a video-slide synchronized presentation. These presentation-vignettes will be collated depending on the lecture. All the proteomics presentations represent sub-topics of the lecture “Proteomics Web Resources”. Online, the presentations will be created as links within the folder for the lecture. Students will be able to access all of these presentations for that lecture. This also serves a dual purpose. Since each presentation is available as a stand-alone link, using UAB’s Blazer ID access, UAB students (even those not registered for the GBS module) will be able to access each video independently. If, for example, a student or researcher wishes to know about protein families, he or she will be able to access the presentation related to protein families. This presentation will be associated with a link to a demonstration of the web-resources, Pfam and ProtDom.

Evolution of Bioinformatics Resources

The Bioinformatics one-month module has been part of the core curriculum through GBS since 2011. As the course is developed and improved, it is likely that there will be some fluidity to the content. More content will added, as lecturers with different expertise become available, some content will be removed, in keeping with the evolution of the topic covered in a presentation. We currently have the lecture videos and slide-presentations available for courses taught since 2011, even if specific lectures were not repeated in 2012, and some topics taught in 2011 and 2012 are not likely to be repeated in the future. As long as the topics are relevant, we will make available video or split-screen presentations of topics and sub-topics on a dedicated server. This will allow users to access information relevant to their research even if the topic is not currently being taught. The author and course-master of the module will work with the instructor for a specific topic to add newer topics within the sub-domain being taught. Specific lectures then need not be repeated. If the topic has evolved, newer topics can be added without having to re-create an entire lecture. If a sub-topic is added to a lecture the link for this short video will be added to the list of topics within the lecture. The author has created movies that combine screen captures of slides as well as use of web-resources for a proteomics lecture. Thirteen such movies exist. The longest of these—how to use the PDB—is less than 15 min long. It is easy to add to this list, without having to repeat the movie (presentation)-making process for resources already in the system. Each presentation is then added to the knowledge base, and can be accessed, potentially, in perpetuity, within the context of a bioinformatics course as well as for research purposes.

Clearly, given the burgeoning number of web-resources available, evidenced by dedicated issues in journals such as Nucleic Acids Research, it is not possible to make a presentation of every resource available. The aim however, is to allow students who might not be computer or Internet savvy (which is less likely among the current generation of graduate students) to be able to familiarize themselves with how to effectively use bioinformatics resources. The plan for the immediate future is to reduce the in-class interactions between students and lecturers, to provide a test basis for the effectiveness of this mode of education, not just as a supplement, but for presenting the basic lecture content. Because the GBS requires that there is contact between the lecturer and the student, whenever an online presentation is made available, students will be required to access the presentation online prior to coming to class. In class, discussions will be associated with raising questions for the lecturer, who will lead the discussions. The effectiveness of the introduction of online presentation vignettes, plus class discussion, as opposed to 100 % in-class interactions, will be assessed during course evaluations.

Psycho-Ergonomic Issues

The challenges of developing an online paradigm for education, especially bioinformatics education, can be viewed from two perspectives: the issues faced by the content-creator and those faced by the content users.

The primary issue in creating online content is time. The author's experience has been that a slide show-video synchronization of a one hour and 45 minute lecture takes about five hours. The process involves re-rendering of the video by editing to ensure only relevant content remains and the video quality is sufficient for online viewing. This video and the accompanying slides are uploaded into the software. The video has to be run in its entirety, looking for visual cues and gestures when the lecturer has changed slides. This is the signal to use a mouse click to switch to the next slide. The time taken to make the video does not include the learning curve associated with using the software.

Other modes of creating online educational materials have the lecturer prepare the presentation (audio, video and slides) directly using the software, rather than capturing the live lecture and synchronizing it with the slides. If only a single course lecturer is conducting the whole course, this method may save time, but it may not be feasible for guest lecturers who are not familiar with either the software or this mode of lecturing. To remedy this, the course master has to work with interested lecturers before the beginning of the module. In terms of feasibility, online versions of only a few topics can be made available each year.

Since we plan on adopting the model of dividing the lectures into smaller submodules for the near and long-term future, each existing synchronized presentation will have to be restructured. The video will have to be re-rendered by editing it into sub-topics related to the overall theme of the lecture. For each sub-topic then, the video will have to be uploaded and the associated slides reintroduced and synchronized with the video. For the screen-capture of a web resource a 10-minute screen capture, the capture, editing and voice-over (to ensure proper articulation a script has to be separately written) efforts take approximately two hours.

Content creators with the expertise in a domain or sub-domain are typically scientists (faculty) and given the other job requirements, the content described above can only be made available as and when time permits. Hiring of audio-visual experts as full time employees will alleviate some of the time-effort, but since every presentation represents a different domain, the scientist-expert will have to work with the technician for full-time oversight. Hiring full time employees with technical expertise requires considerable financial investment.

From the perspective of the recipient of the knowledge, questions arise whether online presentations are preferable to in-class lectures. While the consensus is that online lectures do not hamper the education process [23–25] Berner and Adams have reported from one study that video streaming was less well-received than an audio-embedded slide presentation [26]. Any perceived preference (or the lack thereof) has to be processed purely from the standpoint of not mere convenience, but whether the requisite knowledge is being transferred from lecturer to student via the online medium. Consider the evaluation of an in-class lecture where teacher access is guaranteed instantly and dynamically on one end of a scale, and student-access to a slide presentation at the other end of the scale. One would expect that the in-class would rank as ideal, a lecture-video with synchronized slide (or other audiovisual presentations such as a flash video or screen capture would be second) and a slide presentation of the lecture without accompanying or video or sound would be least influential.

Another perspective that must be taken into account in planning blended learning activities such as described above is the students' time and effort. As discussed in Chap. 2, for a face-to-face class, students and instructors spend the same amount of time (contact time) in class. In the plan for students to view the online lectures in advance and then come to class for discussion, students will spend more time viewing lecture materials than with the instructor discussing the same materials, and it may be much more if they view the lecture multiple times or if the discussion takes the full amount of time that was usually delegated to lecture and discussion. Although the student will undoubtedly learn more with that extra time, the instructor should anticipate what is reasonable for students and plan accordingly.

Conclusions

Presented in this chapter is a description of a plan for online bioinformatics education. Topics and sub-topics within the domain of bioinformatics are presented in vignettes that are very specific to the area of bioinformatics being discussed. These presentations take the form of video-slide synchronized presentations that are available online. Whenever available a video-capture of the use of the online resource edited to highlight important aspects of the access of the resource is available as a link. If the use of the resource is part of a lecture, then a flash video of the video-capture can be synchronized with the video of the lecture.

Such a framework ensures that a knowledge-base of bioinformatics educational information keeps growing as more content is added. A presentation once made and completed does not need to be made again, and is potentially available in perpetuity, unless the knowledge pertaining to the topic of the presentation evolves or becomes otherwise defunct.

All the presentations associated with the topics discussed during a lecture can be collated for a lecture. At the same time, each presentation is stand-alone and can be accessed by students or researchers who will benefit from the knowledge of the resource being presented. Such an educational model is extensible to virtually any domain of the biomedical sciences.

Also discussed here are the potential challenges that one is likely to encounter. These challenges are infrastructural, technical, contextual and intellectual. The primary issue is the time investments that need to be made by the creators of content. A dedicated staff of technical experts will alleviate some of these issues.

Judging from the online educational entities that have been created in the last few years, it is apparent that online education, just like online interactions in almost every walk of life, is here to stay. Bioinformatics is an ideal vehicle for online education because this is one domain that contains two types of practitioners: the developer and the applications specialist or end (or power) user. It should be the endeavor of every biomedical researcher to be an applications specialist; an online bioinformatics education would benefit these individuals the most.

The ability to use computer-driven technology to address biological problems initially was considered revolutionary. One might surmise that there is still a gray area as to not only what constitutes bioinformatics, but how it might be applied, and how far reaching the applications might be. Ouzonis has averred that bioinformatics as a scientific discipline has had its infancy, adolescence and adulthood and will not find any additional use [32]. It is this author's contention that, given recent developments, it would be premature to announce the demise of bioinformatics. One has to, however, adopt a wait-and-watch approach when it comes to defining bioinformatics. It would be preferable to define bioinformatics loosely and broadly to take into account all potential future developments in this discipline.

Certainly, Dr. Searls' long list of potential coursework (albeit through different tracks) [20] further confuses the issue as to what core areas need to be covered. It is not feasible for a would-be bioinformatics specialist to undergo formal training where he or she takes all the recommended courses. Some have indicated that after some basic formal bioinformatics training, practitioners should engage in self-learning, with efforts targeted at obtaining education as and when a problem or a challenge presents itself. Clearly, online educational modalities will play a key role in both formal education and the ongoing problem-based self-directed learning that will follow.

Key Take-Away Points

- Because of the availability and size of data that needs to be efficaciously processed, it is incumbent on experimental scientists to recognize the role of bioinformatics.
- While experimentalists are not required to acquire bioinformatics developmental skills, awareness of tools, especially as they relate to their research domains and sub-domains, will be increasingly critical.
- Exclusively online or online-supplemented in-class bioinformatics education has to be targeted towards the experimental biomedical scientist.
- There will need to be a greater reliance on online systems for the development of continually evolving resources that allow access to specific instances of bioinformatics-driven knowledge for experimental scientists at every level (from student to senior scientist).
- The modalities described in this chapter are extensible to every domain of biomedical science and beyond.

Acknowledgements The author is grateful for support from UAB Center for Clinical and Translational Science (CCTS) (UL1RR025777) and NIH's R21DC011068 (National Institute for Deafness and Communicative Disorders).

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Chapter 12
Clinical and Translational Research Informatics Education and Training

Peter J. Embi and Philip R.O. Payne

Abstract Clinical and translational research often involves the generation, collection, storage, management, analysis, and dissemination of heterogeneous and multi-dimensional data, information, and knowledge resources. Addressing such fundamental informatics needs and requirements is a challenging problem that usually requires the collaboration of multi-disciplinary teams. Central to the ability to form and operate such teams is the development of a workforce with sufficient expertise at the basic and applied science levels as relevant to the clinical and translational science domain. Over the last decade, significant advances have been made in education and training programs targeting such workforce development. While still early in their maturity, such efforts have already begun to impact the advancement of biomedical science and human health, and serve to illustrate the critical nature of computational and informatics theories and methodologies across the broader translational research spectrum.

Role of Informatics in Clinical and Translational Science

The modern biomedical research domain has experienced a fundamental shift towards integrative clinical and translational research. This shift has been manifested in a number of ways, including the launch of the NIH Roadmap initiative [1–3] that has resulted in the creation of the Clinical and Translational Science Award (CTSA) program [3], as well as the rapid growth of high-throughput bio-molecular technologies and corresponding bio-marker-to-phenotype mapping efforts [4]. A commonly reported thread in a broad variety of reports and

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_12,

commentaries concerned with this evolution focuses on the challenges and requirements related to the collection, management, integration, analysis, and dissemination of large-scale, heterogeneous biomedical data sets [5–8]. However, well-established and broadly adopted theoretical and practical frameworks intended to address these needs are still lacking in the biomedical informatics knowledge base [7, 9, 10]. Instead, the development and execution of integrative clinical or translational research is significantly limited by the propagation of "silos" of both data and expertise.

A critical need in overcoming such barriers to the efficient, timely, and impactful conduct of clinical and translational research is the development of a biomedical and informatics workforce educated and trained to make contributions both by leveraging informatics capabilities to accelerate biomedical research and to advance basic and applied science in the field of biomedical informatics itself.

As the conduct of clinical and translational research is an information-intensive task, much work at the intersection of biomedical informatics and biomedical research is needed and has, in fact, been ongoing. Indeed, in recent years, the application of biomedical informatics principles, approaches and tools to the conduct and support of clinical and translational research has evolved. The result is the emergence of two complementary biomedical informatics sub-disciplines that have arisen in response to the unique challenges and opportunities facing research, namely Translational Bioinformatics (TBI) and Clinical Research Informatics (CRI). While definitions vary, we will define these two sub-disciplines as follows:

- **Translational Bioinformatics** (**TBI**) is the sub-discipline of biomedical informatics concerned with the development of storage, analytic, and interpretive methods to optimize the transformation of increasingly voluminous biomedical data into what has been called P4 medicine (predictive, preventive, personalized and participatory) [4, 11, 12]
- **Clinical Research Informatics** (**CRI**) is the sub-discipline of biomedical informatics concerned with the development, application, and evaluation of theories, methods and systems to optimize the design and conduct of clinical research and the analysis, interpretation and dissemination of the information generated [5].

Given that these domains of TBI and CRI are both complementary and critical to the conduct of clinical and translational research these two sub-disciplines can collectively be referred to as **Clinical and Translational Research Informatics** (**CTRI**), and this overarching sub-domain of biomedical informatics is what we will focus on in this chapter.

As depicted in Fig. 12.1, the combined sub-domain of CTRI overlaps with, and complements, the related, but distinct, informatics sub-domains concerned with aspects of basic and early translational science (e.g. bioinformatics), clinical practice (e.g. clinical informatics), and population health (e.g. public health informatics). This range of domains has been referred to as the translational research spectrum

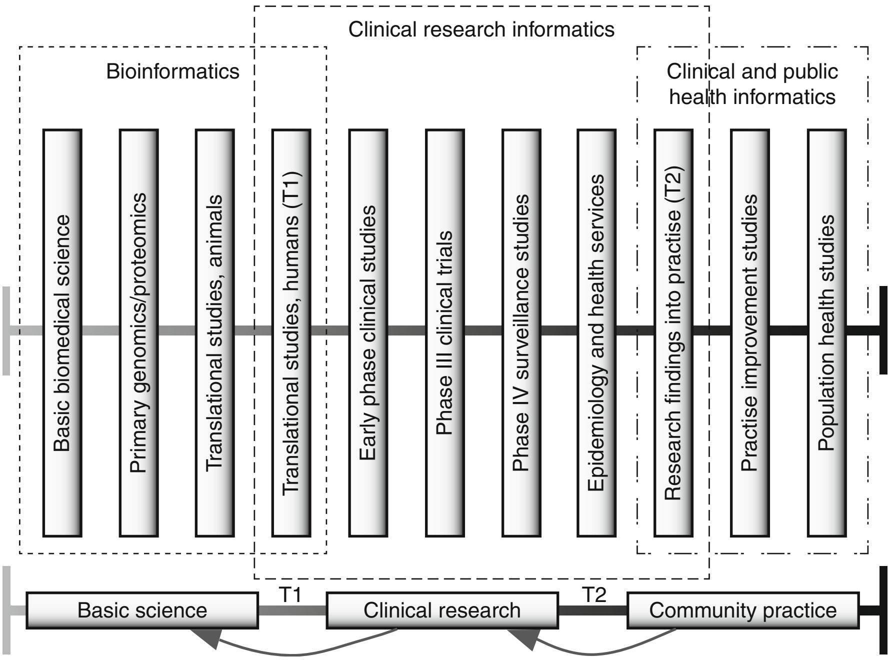

Fig. 12.1 Illustration of types of research across which CTRI is focused, and the relationships between CTRI and the other sub-domains of translational bioinformatics, clinical informatics, and public health informatics. These relationships also parallel the focus areas and methodologies associated with the clinical and translational science paradigm, including the commonly referred to T1 and T2 blocks in translational capacity (where the T1 block is concerned with impediments to the translation of basic science discoveries into clinical studies, and the T2 block with the translation of clinical research findings into community practice) (Reprinted with permission from BMJ, which holds the copyright, from Embi and Payne [5])

with multiple points of translation as shown in Fig. 12.1. As such, it is evident that CTRI spans the T1 and T2 ends of the translational research spectrum.

Challenges and Opportunities of CTRI

Management of Heterogeneous Data Sets

The ability to collect and manage heterogeneous data sets with increasing levels of dimensionality is a significant challenge. The dissemination and adoption of advanced information management platforms that will allow researchers and their staff to focus on fundamental scientific problems rather than practical informatics needs are critical to reducing the burden of managing large multi-dimensional data sets [7, 10, 13, 14]. Central to the ability to realize this opportunity is the imperative that the semantics of such data be well understood and made actionable relative to such operations [15–17].

Appropriate Methods and Tools

The need for knowledge-anchored methods and tools intended to enable the discovery, query, and integration of local distributed data, information, and knowledge resources is critical. This challenge is particularly pressing in multi-disciplinary team-science programs. The challenge is compounded by the fact that knowledge needed to discover, query, and integrate heterogeneous data, and information is often spread over a variety of sources [15]. The utilization of knowledge sources by scientific end-users is significantly hampered due to a lack of easy-to-use tools for knowledge resource discovery and information retrieval. Development of such tools is an opportunity for informatics.

Workflow Facilitation

The provision of systematic and extensible platforms capable of expediting workflows for knowledge integration and analysis is critical to discovery science paradigms. The challenge in facilitating workflow is exacerbated by the lack of availability of systematic data and knowledge "pipelining" tools that are capable of supporting the definition and reuse of computational workflows incorporating multiple source data sets, contextual knowledge sources, intermediate data analysis steps and products, and output types [18, 19].

Workforce Needs

As illustrated by the challenges and opportunities facing the CTRI sub-domain, there exists "…a major need to educate informaticians, clinical research investigators/staff, and senior leadership concerning the theory and practice of CTRI. Such education was thought to be necessary to ensure appropriate expectation management; adoption/utilization of CTRI related methods or tools; and the allocation of appropriate resources to accomplish organizational aims" [5].

Such programs enable the creation of a critical pipeline of experts and thought leaders needed to drive CTRI as a discipline, expanding the current state of clinical and translational research informatics education in general.

Indeed, for the reasons stated above and due to significant progress in recent years, CTRI has emerged as a distinct discipline in its own right. Initiatives such as

Table 12.1 Educational program applicability by learner stage/role

	Tutorial	Multi-week course	Certificate program	Master's degree (or PhD)
Student/resident, clinicians, faculty, leadership	**X**	x		
Investigators, research staff, or informatician liaisons	x	**X**	x	
Informatician, investigator, or research staff who will use or support research informatics		x	**X**	x
Informatician with research informatics career focus			x	**X**

X most applicable, *x* possibly applicable

the NIH Roadmap's CTSA program noted above have helped to galvanize the CTRI community and drive important work in CTRI with the goal of advancing clinical and translational science.

Amidst these ongoing efforts and the progress that has recently been made in CTRI both nationally and internationally, it is recognized that the numbers of IT, informatics, and research professionals trained in CTRI is quite small and inadequate to support the advancements needed if we are to reap the benefits promised by this field.

In order to develop an adequately trained workforce with expertise in the critically important and emerging domain of CTRI, a range of new programs have been under development in recent years. Such programs enable the creation of a critical pipeline of experts and thought leaders needed to drive CTRI as a discipline, expanding the current state of clinical and translational research informatics education in general. Those involved recognize that there are multiple levels of education and training needed to expand the research informatics workforce, including a variety of related but distinct programs that will serve audiences needing different levels of training/educational intensity based upon their career goals and job-requirements. These range from short tutorials, to intensive courses, to certificate programs, to formal training culminating in Masters or PhD level education in CTRI.

The different levels of education for learners at varying levels of intensity based upon their stage of training, their role in the research and informatics/IT enterprise, and their career goals guide such program development. A description of the varying types of learners and the related types of training that would likely be relevant/of interest to such groups of learners is depicted in Table 12.1. As the chart depicts using different size marks, learners in each category on the left may opt for more or less intensive training, but we have indicated with the large "**X**" those offerings we think most appropriate to each type.

To date, such programs are few and far between. However, there are some being delivered at the time of this writing, such as: (1) in-person and online "short courses" in CRI; (2) CRI online training programs; (3) Certificate programs in "Clinical and

Translational Research Informatics" via online, distance-learning. A discussion of the curricular content areas will follow, but first we will lay out the different types of education and training opportunities that tend to dominate the current CTRI landscape.

Tutorials and Short Courses

In order to provide a basic understanding of clinical and translational research informatics to a wide audience including students, clinicians, research personnel and even institutional leaders who may not require or be interested in more intensive and lengthy programs of study, some research informatics "short-courses" or tutorials have been developed. Such courses typically consist of a truncated subset of information from a more intensive weeks-long research informatics course, such as the one described below and are delivered both online and in-person.

One such example is a three-hour tutorial offered twice yearly at spring and fall national informatics professional meetings. Online versions of such courses are also under development. The goal of such a program is to familiarize the groups listed above with the basic concepts, goals, and utility of biomedical informatics approaches as they relate to advancing both the generation of evidence (i.e. through research as well as through common data collection, subject recruitment, and other activities) and the translation of research knowledge into practice.

Driven by the recognition of the importance of education and training focused on research informatics to ensure optimal use of information resources and capabilities across the research enterprise, some have also developed and deployed formal educational programs specifically focused in the CTRI space. One such example is a clinical and translational research informatics online training program developed by Embi and colleagues in collaboration with the American Medical Informatics Association's (AMIA) 10×10 initiative [20]. This 10×10 program provides students with an intensive survey of the field of CTRI delivered mostly via distance-learning, with a concluding face-to-face session that takes place at an AMIA national meeting. Using state-of-the-art asynchronous distance education resources and techniques, the program incorporates multiple modes of learning and participant interaction including weekly voice-over-PowerPoint lectures, threaded discussion forums, online knowledge assessments, and a class project that is presented during a concluding face-to-face session. The audience includes: (a) investigators interested in learning more about CTRI's relevance to clinical/translational research, (b) informaticians who are interested in strengthening their knowledge of CTRI as a subdomain of biomedical informatics, and (c) other students interested in the domain, such as those from the biotechnology or pharmaceutical industry, government, etc. A typical course schedule/curriculum for the 10×10 program is depicted in Table 12.2.

Table 12.2 Curriculum for clinical research informatics 10×10 course

Week	Compentencies (at the conclusion of this session students will be able to:)
1. Course overview and general biomedical informatics principles	Discuss the goals of the course
	Discuss basic principles of biomedical and health informatics including health system architectures, evaluation, etc.
	Discuss definitions of biomedical informatics and of the clinical research informatics subdomain of biomedical informatics
	Discuss the major challenges and opportunities facing the CRI domain.
2. Overview of clinical research	Discuss the definitions and types of clinical research and the related areas of translational research
	Discuss basic principles of clinical research including the research process, aspects of study design, data collection and analysis, etc.
3. Informatics applications in clinical research, part 1	Discuss the application of research-specific informatics approaches and tools in clinical research
	Discuss the uses of general informatics systems as applied to clinical research
	Discuss informatics methods and tools applied to research hypothesis development
4. Informatics applications to clinical and translational research, part 2	Discuss informatics methods and tools applied to protocol development
	Discuss informatics methods and tools applied to patient recruitment
	Discuss informatics methods and tools applied to adverse event surveillance and pharamcovigiliance
	Discuss informatics methods and tools applied to dissemination and utilization of research findings
5. Research data collection, management and analysis	Discuss current best practices and principles for data collection, management and reporting
	Discuss methods and tools applied to research data collection
	Discuss methods and tools applied to data analysis and reporting
6. Enterprise systems in CRI	Discuss principles and practice of research database and data warehouse development
	Discuss the key elements and features of clinical trial management and electronic data capture systems
7. Data and knowledge standards in CRI	Discuss the importance of standards, terminologies and models in biomedical informatics
	Discuss ontology and model initiatives in CRI
8. Regulatory and ethical issues in CRI	Discuss key issues in privacy, confidentiality and research oversight relevant to CRI practice
	Discuss key ethical considerations in research informatics
	Discuss key principles and tools for trial registration and results dissemination
9. Translational research informatics, and CRI-BMI overlaps	Discuss the applications of informatics principles of translational science (both T1 and T2)
	Discuss the overlap of clinical research informatics and related domains of clinical informatics, translational bioinformatics, and public health informatics
10. Review major CRI initiatives and future directions	Discuss major national and international initiatives driving the CRI Agenda
	Discuss key CRI directions for the future

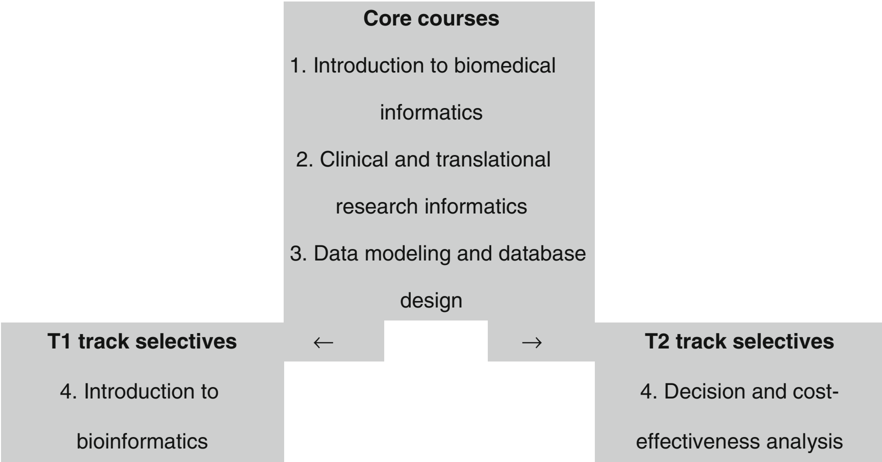

Fig. 12.2 Example curricula for certificate program enrollees, branched into T1 and T2 example tracks

Certificate Programs

Beyond tutorials and short courses, there exists another level of training programs in CTRI that lead to granting of formal university-based certificates and that are often delivered via online/distance-learning offerings. The programs typically draw upon and leverage courses from CTRI tracks of Masters or PhD level curricula, though some are stand-alone. Typical certificate programs include a five-course series consisting of core courses and tracks with the ability for partial customization to suit learners (Fig. 12.2). Courses include such titles as: Introduction to Biomedical Informatics; Clinical and Translational Research Informatics; Decision Analysis and Cost Effectiveness Analysis; and Quality Improvement and Patient Safety; Introduction to Bioinformatics; Computational Genomics; Data Modeling and Database Design; IS/IT Architecture; JAVA Programming for the Enterprise; and Introduction to Research Methods and Biostatistics.

Sometimes, those who start off with the short-course option, will transition to the certificate to gain further knowledge. Typically, enrollees work with their advisor to determine whether they should pursue a T1 or T2 focused program of coursework, or “Track,” based upon their interests, background, and career goals. That is, those who are interested in either a T1 (research informatics as applied toward the T1 end of the translational spectrum) or T2 (research informatics as applied toward the clinical/population health end of the translational spectrum) emphasis, follow a customized “track” focused more so on bioinformatics or clinical informatics respectively, as appropriate. Figure 12.2 demonstrates example curricula for each track students might pursue.

Masters, PhD and Fellowship Programs in CTRI

For those who will focus on CTRI as their primary area of emphasis in a biomedical informatics career, formal training at the masters, doctoral, or fellowship level is appropriate. Training programs have been developed with just such a focus, and provide exploration of exemplary data, information, and knowledge management challenges and opportunities that exist as the intersection of biomedical informatics and both clinical and translational science. Such programs tend to offer a foundation in biomedical informatics, with an emphasis in issues unique to the CTRI subspecialty.

Lessons Learned

When viewed in a holistic manner, the preceding CTRI-focused training landscape and its historical evolution serve to elucidate three important lessons learned, as enumerated below.

Tailoring the Focus of the Curriculum for Different Learner Roles

One key lesson learned by the CTRI community has been that there are a variety of types of individuals who require training and expertise with regards to the domain. For example, some individuals seek training in order to support or enable their ability to serve as CTRI practitioners, wherein they might be responsible for the development, management, and support of various technology platforms and interventions targeting the clinical and translational science domain. Other individuals may seek training in order to inform their pursuit of innovative and novel scientific studies concerned with biomedical informatics theories and methods that may serve to address the clinical and translational research information needs. Finally, individuals in leadership or decision making roles (e.g., policy makers, etc.) may seek training in CTRI in order to inform their analysis and understanding of critical policy, financial, and socio-technical issues with relevance to clinical and translational research that they may need to address.

Each of these types of individuals requires a different type of training, which can be generally differentiated based upon: (1) its breadth (coverage of domain) vs. depth (level of detail); (2) its degree of theoretical vs. application-level orientation; and (3) its focus on different aspects of the research cycle and translational spectrum. For example, clinical and translational researchers who are not primarily CTRI practitioners may need training that has significant depth and application-level orientation with a moderate level of breadth in CTRI, focusing on particular research areas they will be responsible for in their professional research setting. On the other hand, informaticians who want to specialize as CTRI investigators or researchers may need both a broad and theoretical grounding in the field with a high degree of depth into CTRI areas so as to ensure that they possesses a rigorous, strategic, and methodological understanding of the domain. Finally, policy or decision makers may need a great deal of breadth of understanding of the field, with an equal treatment of theory and applications-level foci, and a low level of depth. All of the aforementioned scenarios illustrate and continue to argue for highly tailored approaches to the design and delivery of CTRI training based on audience type and composition.

Differentiation of Acculturation vs. Training to Determine Type of Instruction

A related lesson that emerged from the ongoing development of CTRI training programs is that it is important to differentiate among the various CTRI roles and how these roles influence the needs of such individuals for either acculturation or training in the field. This differentiation will influence the type of course that is offered. In such a context, acculturation can be thought of as the process of gaining a "survey" level of understanding of the salient issues surrounding a domain, without gaining the theoretical and/or applied skills necessary to pursue practice or research in that area.

In contrast, training is more concerned with the preparation of individuals to actually pursue practice or research in an area. In the CTRI domain, given the diversity of potential stakeholders, there is a corresponding need for both types of education. For example, principal investigators of clinical or translational research programs may need to be acculturated to understand basic concepts and trends in CTRI so that they can efficiently interact with CTRI professionals, but do not necessarily need to gain a deeper level of understanding of underlying theories and methods. In contrast, individuals in the practitioner or investigator roles, as described in the preceding lesson learned, will need a far greater level of understanding regarding the field, necessitating in-depth training. To generalize, acculturation is a type of training need that can likely be achieve via seminars, workshops, and brief tutorials, while training likely requires formal degrees, coursework, or certificate programs, to name a few of many options.

Need for Alignment with Cross-Cutting and/or Foundational Biomedical Informatics Theories and Methods

Finally, as the maturation of CTRI training and education has progressed, it has become increasingly apparent that such efforts need to more carefully and systematically align competencies and curricula with cross-cutting and/or foundational biomedical informatics theories and methods. It is only though such alignment and harmonization that the emergent CTRI community and its members can benefit from historical and empirically evidenced trends in the broader biomedical informatics community (thus realizing the primary advantage of history, namely the ability to learn from it). For example, CTRI investigators and practitioners who seek to explore how EHR platforms can be leveraged to support/enable clinical trial recruitment can and should learn from, and apply, the lessons learned as well as basic theories and methods associated with the clinical informatics community's pursuit of advanced clinical decision support and guideline delivery systems. As such, curricula and education/training programs targeting such CTRI focused individuals need to "interweave" such cross-cutting or foundational knowledge into evolving and CTRI-specific competencies and coursework.

Conclusion

The field of CTRI is advancing rapidly, and there is a great and growing need to educate and train a range of personnel in the theories, methods, resources and regulatory and ethical issues unique to the CTRI domain. As an emergent and rapidly evolving sub-discipline of biomedical informatics, CTRI can extend core theories, methods, and historical lessons from the parent field. Because the CTRI workforce is growing at an accelerated rate, both education and training programs need to continue to develop and be evaluated in a similarly rapid manner. The ongoing efforts such as those illustrated above are beginning to address these educational and training needs to address this important area.

Key Take-Away Points

- CTRI researchers and educators should capitalize on the theories, methods and activities in the broader biomedical informatics domain.
- Multiple training and education scenarios exist to satisfy the need of the CTRI workforce, including formal coursework and degrees, as well as more topical workshops, distance education, and certificate programs.
- The delivery of CTRI education and training can and should be tailored to meet the variable needs, stakeholders, and roles incumbent to the clinical and translational science community, which by necessity also requires the differentiation of training versus acculturation to the field.

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Part IV
Informatics Education Worldwide

Chapter 13
Translating U.S. Informatics Educational Programs for Non-U.S. Audiences

John H. Holmes and Jeffrey J. Williamson

Abstract A great deal of informatics educational content has been and continues to be created in the United States. It is incumbent on U.S. educators to consider translating and disseminating such content globally, with the goal of collaborating with other countries to increase informatics professional capacity worldwide. While there are numerous constraints to this endeavour, such as organizational, technological, and cultural differences between the U.S. and other countries or regions, these are not insurmountable. The use of information and communication technologies in the service of disseminating educational materials for informatics training considerably mitigates these constraints, and sensitivity to the needs and customs of countries and regions targeted for educational content dissemination will help to ensure successful implementation of this training.

Informatics is a field with a rich history and is continuously evolving as an academic discipline. The growth of educational materials, such as curricula, course descriptions, syllabi, lecture notes, reading lists, archived webinars, and other multimedia materials, and textbooks, documents the growth of the field of biomedical and health informatics. In a real sense, these materials provide evidence of a maturing profession dedicated to research and applications of health information sciences.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_13, © Springer-Verlag London 2014

To date, many of these resources stem from educational efforts in the United States. Over the past 20 years, there has been substantial activity in the U.S. that has focused on developing educational programs in biomedical and health informatics. More recently, there has been a rapid development of such programs at academic institutions not usually associated with informatics education. Informatics educational programs in the U.S. exist in a variety of configurations, as described in the previous chapters. There are programs funded by the U.S. government, stand-alone graduate programs, certificate programs, and courses that are sponsored by specialty societies and even private institutions and universities now deliver informatics education. More recently, health informatics programs are appearing at the undergraduate level. While this growth is exciting to education professionals who run informatics programs, there is work to do in clarifying and differentiating the coursework that is delivered at all levels of education, particularly as these projects attempt to translate informatics programs for non-U.S. audiences.

In this chapter, we describe the development of educational programs and content in informatics in the U.S. and avenues for translating these artifacts to settings outside the U.S. The remainder of this chapter is organized as follows. We provide a brief survey of the history of the development of informatics education programs prior to discussing issues associated with the translation and dissemination of informatics educational content to settings outside the U.S. We also review some of the methods for dissemination. These are largely information and communication technology (ICT) tools, but they include others as well, such as onsite, in-person courses. We discuss the regional requirements posed by language, culture, infrastructural support, and educational system structure that all impact the success of disseminating educational content. Finally, we discuss avenues for the future translation of educational content, not only from the U.S., but from other countries as well.

Before examining these sections, a few definitions are needed. We have used the term *dissemination* throughout this chapter to mean making available to a wide audience the educational programs and components or materials that have been developed in or by U.S.-based educational programs. Second, although this chapter refers to *translation*, we will use that term in its truest sense: to *carry across*. We do not intend it to be limited to translation from English to another language, although that is certainly an important consideration. However, it must also include the adaptation of educational materials to locations and cultures outside the U.S., and this includes much more than language. Thus, the difference between the two terms is that dissemination refers to the broader activity of making educational materials available, without consideration of the constraints imposed by cultural or infrastructural requirements of the non-U.S. users. Translation is dissemination that considers these constraints, such that the materials provide the highest utility for the non-U.S. user. Finally, we use the term "educational materials", even though the chapter title uses the term "programs". Program connotes an organizational structure that includes many educational materials, and we certainly consider these. However, there is much to be said for including such entities as single courses, and even stand-alone lectures that exist outside the structure we typically associate with a program.

Background and History: Informatics Training in the United States

There are several key benchmarks in the growth of informatics that are worth mentioning prior to describing the different types of informatics education programs. In the early 1970s, the National Library of Medicine (NLM) funded the initial group of informatics training programs. A few years later in 1976 the Symposium on Computer Applications in Medical Care (SCAMC) was established, providing an outlet for the presentation of scientific research and scholarship. In 1984 the American College of Medical Informatics (ACMI) was founded. A merger of SCAMC, ACMI, and the American Association for Medical Systems and Informatics (AAMSI) resulted in the creation of the American Medical Informatics Association (AMIA) in 1989. In 1992 the NLM introduced a weeklong seminar at Woods Hole offering the first short course entitled an *Introduction to Medical Informatics* and in 1994 the *Journal of the American Medical Informatics Association* (*JAMIA*) published its first issue. These formative events in the United States served as foundational elements for the academic discipline of informatics providing pathways for international collaboration, knowledge dissemination, and growth, both domestically and abroad.

National Library of Medicine Training Programs

The U.S. National Library of Medicine offers grants and funding to biomedical informatics programs through its Office of Extramural Programs (see also Chap. 3). There are 14 programs funded in the latest round of grants in 2012 offering "graduate education and postdoctoral research experiences in a wide range of areas including: healthcare informatics, translational bioinformatics, clinical research informatics, and public health informatics" [1]. Additional programs may offer other tracks of training in specialized areas of informatics, such as dental and imaging informatics. The NLM-funded informatics training programs leverage their grant funding to grow their curriculum and broaden their base of students. The collaboration of the Regenstrief Institute and Indiana University School of Medicine with the Regional East African Center for Health Informatics at Moi University in Eldoret, Kenya is a good example of this approach to international education outreach and training program development. This collaboration is a joint effort supported by the U.S. Agency for International Development (USAID) and Academic Model Providing Access to Healthcare (AMPATH), a partnership with U.S. institutions based at the Moi University School of Medicine. By leveraging the existing informatics program to procure additional funding through the Fogarty International Center of the U.S. National Institutes of Health, the Regenstrief Institute Center for Biomedical Informatics (CBMI) has become a leader in global health informatics. The CBMI has hosted several Kenyan scientists through the years for training in informatics to support the deployment of a medical record system designed for low resource areas that has evolved through the years and is now known as the Open Medical Record System (OpenMRS). As this project has grown throughout Kenya and sub-Saharan Africa, a need for locally trained professionals to support the deployment of OpenMRS stimulated the development of a Bachelor of Science in Informatics program at Moi University [2]. The curriculum that leads to a degree in informatics contains many courses or elements of courses that are commonly found in U.S. based programs.

Stand-Alone Graduate Programs

Stand-alone graduate programs in informatics offer programs leading to a master's or doctoral degree. There are now more stand-alone graduate programs in informatics than any other type. These programs rely on upon institutional funding, grant support, and most importantly student tuition to sustain their academic program. Stand-alone graduate programs can be found in such schools as medicine, nursing, public health, and engineering and they may be located in centers or institutes that combine faculty and students from one or more schools in a university setting.

Certificate Programs

Informatics certificate programs are composed of one or more courses where the student may accumulate academic credit but does not earn a degree. A certificate of completion in a designated area such as health informatics is a common outcome for participation in such a program. Certificate programs are commonly offered either as in-person classroom experiences or online, or a combination of both. These programs usually comprise less than half of the contact hours usually required for a master's degree. The target student for these programs is typically an adult learner or working healthcare professional. These include physicians, nurses, pharmacists, chief medical/nursing information officers, health program administrators, and public health personnel who are looking to supplement their existing knowledge. A certificate of completion from a reputable program confers the recognition that the student has attained a certain level of knowledge and acquired a set of skills that are useful for the practice of informatics in his or her chosen profession. Certificate programs do not ordinarily provide the depth of knowledge or skills that one would need to pursue informatics as a primary occupation, however.

The 10 × 10 Program

10 × 10 is a training program launched and administered through the American Medical Informatics Association with the goal of training 10,000 clinicians in basic

informatics [3–7]. The 10 × 10 program is described in Chap. 8. Shortly after the program was deployed it enjoyed success as a public program with open enrolment, and the need for focused special courses materialized both domestically and internationally.

The 10 × 10 program is one of the earliest examples of the translation of informatics educational content outside the U.S. The 10 × 10 partner at Oregon Health and Science University (OHSU), led by William Hersh, MD, began discussions with AMIA about developing a collaboration with an emerging informatics group in South America that included Paula Otero of Argentina and with a group in Southeast Asia that included K.C. Lun of Singapore. The purpose of the collaboration was to offer a version of the popular OHSU 10 × 10 distance learning course to the local constituencies in Argentina and Singapore who desired a basic informatics education. The OHSU course in Argentina had trained several hundred individuals over the prior three years, so the proposed collaboration merely strengthened an already strong relationship between the two institutions. Then-President and CEO of AMIA Donald Detmer led discussions about advancing the 10 × 10 brand globally through a partnership with Drs. Lun and Hersh, and Jeffrey Williamson, AMIA Vice-President for Education and Academic Affairs. However, financial constraints prevented applying the domestic 10 × 10 business model to an OHSU course that would be administered only through that institution. From this reality, it was determined that a more appropriate model would be to engage educational material providers in countries outside the U.S., and the concept of the "i10 × 10" emerged. The "i" connotes both the international scope and the Internet as a means of dissemination. The i10 × 10 concept was seen as complementing AMIA's desire to collaborate with international partners to disseminate content from U.S.-based programs. AMIA had initiated several projects to increase informatics capacity in low- and medium- resource countries. One was a conference of international leaders in informatics and informatics education held in Bellagio, Italy [8], the Health Informatics Building Blocks project (funded by the Rockefeller Foundation), and the other was the Gates Foundation-funded Global Partnership Program.

The 10 × 10 program is a strong and highly visible means of providing basic informatics educational content. The OHSU program has been translated into Spanish by Dr. Otero, and is in use in Latin America (See Chap. 14 for more information on this program).

In addition, i10 × 10 provides a way for informatics course leaders in countries outside the U.S. to provide content in their region. The criteria for participation in i10 × 10 include (1) a requirement that the program include recognized international informatics faculty and (2) there must be an endorsement of the proposed course by the local or regional member society of the International Medical Informatics Association. The course proposal should include a program description, course design, rationale for participation, and an overview of course administration, which parallels the requirements for approval of a 10 × 10 course proposal from a U.S. institution. Students completing the course receive a 10 × 10 certificate of completion from AMIA. An institution offering an i10x10 course can be located in any country. For example, the OHSU Gateway i10 × 10 program provides courses in Argentina and Singapore [9].

Continuing Education Programs

There are many continuing education (CE) programs for health professionals who wish to acquire informatics knowledge. Membership associations and specialty societies design educational programs after assessing the CE needs of their constituencies. Conferences, workshops, webinars, symposia, tutorials, journal-clubs, and more recently, case-based learning opportunities (sometimes called "boot-camps") provide highly focused subject matter over a period of time ranging from an hour to several days. Enrolees are immersed in these activities and find value in not only the content being delivered but also the opportunity to network with others facing health information technology problems. Because informatics is inter-professional, these organizations are often challenged to produce programs that appeal to the scope and breadth of the health professionals in their target audience.

In order for the field of informatics to continue to grow, there must be the recognition that the many educational resources that have been developed, and will continue to be, should be made available to as wide an audience as possible. Whether these resources are distributed under a revenue-based business model or one that is open and supports the free dissemination of educational material is determined by the developer or the provider. There are potential constraints to making available such materials, and these are discussed later in this chapter; however, the assumption here is that sharing of educational resources across the globe is good for the profession, its students, and society at large.

A Growing Consensus of Informatics Educational Requirements

With the burgeoning of educational programs in informatics, there appears to be a growing need for consensus about the academic requirements, organization of faculty, and management of educational and research programs focused on informatics in U.S.as well as non-U.S. universities and colleges. This is evidenced by numerous publications in the informatics literature [10–28]. Scholars and subject matter experts are taking the issues and challenges around core competencies, certification, and accreditation more seriously than ever. This can only benefit those individuals looking to leverage content for healthcare educators and professionals in other parts of the world.

Many informatics education programs collaborate to formulate guidelines and best practices for education and training. These are disseminated nationally and internationally through informatics communities of practice. Communities of practice include entities like the AMIA Academic Forum, a body of educators, administrators, and other representatives from academic institutions who are dedicated to serving the needs of post baccalaureate biomedical and health informatics training programs. The Academic Forum now has international members from Argentina and Australia with members from other countries expected to emerge in the coming years.

Translating and Disseminating Educational Content

As noted in the introduction to this chapter, there are many types of items that could be candidates for translation to other audiences outside the U.S. However, one must consider several important constraints that affect the translation of educational content from the U.S. to other countries. These fall into two broad classes—those that affect the U.S. provider and those that affect the non-U.S. consumer. The U.S. provider is typically a university, healthcare system, or a public health agency, and the content creator is an employee of the provider. This is an important distinction in many settings, because of the question of who owns the intellectual property that is the educational content. Even though a faculty member had designed a course and created all of the educational materials for the course, in most cases that course and all artifacts that are associated with it are the property of the university. This is because the faculty member was working as an employee of the university. The concept of intellectual property ownership is not universally understood across the U.S., however, and a thorough examination of its implications for each type of setting where educational materials might be produced is beyond the scope of this chapter. Intellectual property issues are clearly a first-order concern when disseminating educational materials to users outside the entity, and this is particularly acute when these materials are expected to generate revenue.

Another constraint that one must consider in translating educational content from the U.S. to other countries is sensitivity to the cultural, social, and organizational contexts of the target country. In the U.S., we sometimes take the context for granted, and sometimes to our detriment, but educational materials based on U.S.-centric knowledge and experience do not necessarily translate well to non-U.S. settings. Perhaps the most obvious barrier is language, and this barrier is manifested on at least two levels: the language of common communication, and the language of technology. Communication in English in a non-English speaking country is certainly challenging, and might actually be inappropriate. One would expect that educational materials developed in English but destined for, say, Croatia, would be translated into Croatian, a non-trivial task that requires a native speaker to supervise that endeavour. Second, even when the target audience is English-speaking, complicated, systems-related concepts that we in the U.S. represent with a language of acronyms and abbreviations require considerable decompression and description. Of course, translating these concepts is doubly-difficult when the target language is not English.

A third potential barrier is the difference in organizational structures between the U.S. and other countries. For example, healthcare delivery models in non-U.S. countries are often quite different from the employer-based healthcare insurance model in the U.S. So-called "socialized medicine" as seen in many other countries exerts a different impact on how health information is gathered, maintained, analyzed, and made available to others.

A fourth barrier is the difference in professional roles. For example, in countries like the United Kingdom, the primary care physician ("GP") serves as the gatekeeper for a patient's care and is the only practitioner who can prescribe medications or order tests and procedures. This organizational structure has implications for translating U.S. educational content to this kind of setting. Users of the electronic health record (EHR) in the U.S. are vastly more diverse, from across a wide range of health professions.

Fifth, regulatory differences that exist between different countries and the U.S. pose potentially difficult barriers for the U.S. educator wishing to disseminate informatics content. For example, privacy and confidentiality regulations in the U.S. are considered by many to be the strongest in the world, but in reality, there are many regions where ministries of health and other governmental bodies have imposed even stricter constraints on the use of identifiable health information. Such regulations need to be observed rigorously on the part of U.S. educators as they develop course material on such topics as network and system security, master patient indexes, and data archiving. As in the U.S., these regulations usually apply to both clinical practice and research. Other regulations such as those applying to data and communication standards may be different than those in the U.S., and curricula should be developed with sensitivity to these as well.

Finally, organizational, administrative, practitioner, and financial capacity can exert substantial effects on the ability to translate informatics educational content from the U.S. to other countries. It does little good to focus a course on an expensive, complicated electronic health record system that could not be implemented in a region due to cost, lack of experienced systems personnel, or even network or electrical power infrastructure. And in a country where there are few practitioners to provide care for a growing population, the priorities of those practitioners are more likely to be focused on providing that care than on embracing a technology that may or may not have any obvious value.

These are typical concerns that affect the viability of any effort to translate U.S.-based and especially U.S.-centric informatics educational content to another country. There are undoubtedly others, such as difficulties in disseminating online content [29] and these are likely to be vary on a country-by-country basis. The most important principle to guide the translation of an educational program or course is that the course developer must always be cognizant of the needs of the target audience, and this often involves considerable investment of resources in order to develop educational content that is meaningful and useful to those in the target audience. One way we can effectively translate and disseminate this content is to explore and use methods that take advantage of whatever technological environment is available in the targeted country. Several of these methods are described in the next section.

Methods for Disseminating Educational Content

Onsite, In-Person Dissemination

It is probably true that in most cases, face-to-face instruction, in person, and in real-time, is the ideal method for disseminating any educational content, and informatics content is no exception. Especially in a discipline that relies heavily on demonstration and hands-on experience with software tools, such an educational experience should be considered whenever possible. However, this is not always practical, especially in situations where students are not able to assemble in a single location because of travel constraints. In these cases, online learning environments provide a cost-effective, resource-sparing means for disseminating content to students. These environments can also enhance the educational experience for instructors and learners through feature-rich software that has been developed over the past decade.

Online Learning Environments

Online dissemination of informatics educational content is rapidly becoming the preferred method for training, although it is not without its challenges, for the reasons described above. Learning management systems (LMS), or virtual learning environments, are web-based software tools that provide support for a variety of communication modalities, including discussion boards, email, and real-time interactive communication. Moodle [30] is an example of an open source LMS that is freely available and distributed under the GNU General Public License, and is an attractive option for dissemination to low-resource countries. Blackboard [31] is a well-known proprietary LMS that has a worldwide market. In between these systems, there are numerous LMSs that support a wide variety of instructional needs. Most LMSs support both asynchronous and real-time dissemination of educational content.

Asynchronous Methods

Asynchronous methods of disseminating content online support the posting of material such as documents, slide sets, lecture notes, and multimedia. Communication between instructors and learners (or between learners and other learners) occurs not in real time, but by means of posts that are read and replied to at some point after the posts are made. The simplest methods for asynchronous dissemination include discussion boards and email, which support limited content depending on the software environment. One type of asynchronous dissemination method is the archive of previously recorded real-time content, such as webinars and lectures. These materials can be placed on websites for viewing at learners' convenience.

Real-Time Methods

Interaction between participants in an online educational environment ideally occurs in real-time. In this way, learners and instructors provide and receive nearly instantaneous responses to questions and can engage in discussions as if they were communicating face-to-face in a classroom. Webinars provide one means for learners to experience educational content such as lectures and discussions in a real-time online environment. In a webinar session, an instructor can present a lecture using any assistive technologies, such as PowerPoint and multimedia that could be used in any lecture setting. Translation from one language to another for live webinars would demand simultaneous translator services, although an archived presentation could be translated after it is created, and it would likely be easier to perform that translation into more than one language. Translating the materials displayed on the screen would pose a more difficult challenge, since this cannot be accomplished easily in real time. In any event, the dissemination of a presentation to multilingual audiences is possible, using multiple versions of the presentation in the target languages.

A more challenging problem involves disseminating webinars in developing countries, where broadband connections may be unavailable or unreliable. Webinars require substantial bandwidth, owing to the use of audio and especially complicated and dense video. For example, a typical webinar will display an instructor's computer screen with a PowerPoint presentation, perhaps with complex graphics, photographs, and movies. This type of presentation will not be viewable if the capacity of the broadband connection is substandard, say less than 5 Mbps.

These challenges aside, the webinar is an excellent medium for disseminating informatics training and educational content. In addition to providing the potential for real-time interaction with the instructor and other attendees—most webinar providers offer a chat facility—a learner could perform exercises online, perhaps using print material supplied in advance, or online problem sets, much like one would experience at the blackboard in a real classroom. Another advantage to the webinar platform is, as noted previously, its archivability. This is important for allowing those who cannot attend a live webinar due to scheduling conflicts, network outages, or illness. Such learners could go to a website, select a webinar from the archive and watch as if it were live. Of course, they would not be able to participate in discussions or other events that occurred during the live webinar, but there could be added some educational activity that could be experienced asynchronously, such as a quiz that would be completed and submitted by the learner, and subsequently graded by the instructor.

Another approach to using the webinar platform is to create content offline and then disseminate it asynchronously, in an archive. This approach is often used where the educational material is produced in a studio or other environment, without the interruptions or benefit of live participation. One disadvantage of this approach is that there is no student discussion to archive, so the presentation might not be as rich as one would experience were the webinar captured live with student participation. This kind of webinar is best when the material is to be presented as a simple lecture or demonstration. It is in common use in a number of informatics training programs, such as some 10×10 sites. Like the archived live webinar, this "studio-produced" webinar can be used for asynchronous interactions with the instructor and other students through such resources as a discussion board on a learning management system.

There are a growing number of webinar software programs that support video and audio, and most support real-time remote desktop capture, as well, so that participants can see the host's computer desktop as if it were their own. This feature is important for those who plan to demonstrate software or show slides as part of a lecture. Finally, all of these systems support recording so that a webinar can be archived for future access. Chapter 11 provides additional approaches to using asynchronous webinar-type programs, and Chap. 2 discusses organizational and instructional strategies for distance learning.

Communities of Practice: HIBBs

The goal of a community of practice (CoP) is to establish a forum in which people who work in a particular profession or occupation can share their knowledge and experience. A CoP can exist in physical environments, such as an annual professional meeting, but more recently, there has been increased interest in online CoPs, as evidenced by discussion boards, listservs, and groups. CoPs exist in many professions, and informatics is no exception, with representation in the American Health Information Management Association (AHIMA), the Health Information and Management Systems Society (HIMSS), the Society for Imaging Informatics in Medicine (SIIM), and the American Medical Informatics Association (AMIA), with the last providing an interesting case study.

AMIA was funded by the Rockefeller Foundation to establish a community of practice model for dissemination of informatics training materials throughout the world. The centerpiece of this model was a tool called the Health Informatics Building Blocks (HIBBs), which is a repository of training modules developed by informaticians for those working with or in health information technology and informatics. The purpose of the HIBBS is to provide open-source, shareable, freely accessible (and free) educational materials for the development of skills and knowledge in the creation, management, and use of information. A building block, or module, is intended to be reusable and portable to many different settings; in that regard, they truly are "building blocks" that can be used as components in a larger curriculum or educational program.

The initial modules were focused on informatics practice and education in Africa, and were developed within AMIA in cooperation with the South African Institute for Distance Education (SAIDE) Open Educational Resources (OER) Africa [32]. The HIBBs modules are archived at: http://www.oerafrica.org/hibbs/Modules/tabid/1884/Default.aspx [33] and are available without the need for an account or password. They are licensed by the Creative Commons Attribution-Share Alike 3.0 Unported agreement. This provides substantial freedom in terms of use, allowing the modules to be shared, adapted, and usable for commercial applications, such as tuition-bearing courses, as long as the original work is attributed to the original authors and any subsequent distribution must be made under the license.

As of May 2013, HIBBs includes nine modules on basic computer skills, introduction to informatics, health information systems, electronic medical record systems, ethics and legal issues, data quality, research data, bioinformatics, and change management. There is also a template that can be used to create game-based quizzes for use in classes. The HIBBs repository continues to grow, and although there is no empirical evidence of how these modules are being used in educational settings, it is clear that contributors are motivated to create and share their knowledge of critically important aspects of informatics.

The Future of Translating Informatics Educational Materials for Non-U.S. Audiences

There is increasing interest in establishing collaborations between the U.S. and non-U.S. audiences for disseminating informatics educational content. As more countries and regions outside the U.S. develop the capacity for informatics-assisted healthcare and research, practitioners, administrators, and researchers are in need of highly trained informaticians. With its long history of developing curricula and programs for training informatics professionals the U.S. stands at a unique position to disseminate the fruits of its informatics educators' experience and expertise to other countries where the desire to grow informatics capacity is great.

But there are other countries, particularly in Europe, that stand with the U.S. in this endeavour, and this is manifested in the International Partnership for Health Informatics Education [34]. This organization, founded in 1998, is a collaboration of institutions in Germany, The Netherlands, Austria, Taiwan, and the U.S. to "… promote education through international collaboration of graduate and undergraduate training programs in Medical and Health Informatics."

It is equally important to recognize that the growth of the academic discipline of informatics over the past few decades has occurred not only in North America, but also in other parts of the developed world. Informaticians from Europe, southeast Asia, and South America either have developed or are developing robust informatics programs and training capacity that can complement efforts originating from the United States. Many of these programs are well recognized and highly regarded in the world of academic informatics.

In fact, in interacting and exchanging ideas and teaching practices with colleagues on an international level, it is important to recognize that the exchange of knowledge is bilateral. Informatics research and training programs in the United States are not without their own set of challenges. Exposure to successful approaches during the process of translating content can elevate the international conversation as scholars seek an optimal state of informatics program design. Indeed, this can, and should, occur both in more developed parts of the globe and in low resource areas. The best approach is to recognize that the strategies and solutions developed through cross-programmatic discourse and translation return a rich set of experiences through which all collaborators can benefit.

So what does the future bring when it comes to translating informatics content for use by educators in other parts of the world? We know that programs in the United States exist in many different forms and sizes with administrative homes in schools, departments, centers, and academic units within universities. The lack of uniformity in our informatics training eco-system in the United States means that large-scale, systematic, or enterprise level efforts to translate content can be extremely difficult and fraught with barriers. Challenges are further exacerbated by the difficulty of gaining consensus when multiple stakeholder organizations are involved, even when the stakeholders agree there is a true opportunity or local, regional, or national need.

In conclusion, it is clear that informatics faculty are eager to collaborate based on genuine commitment to developing or elevating the academic discipline to other parts of the world. This is particularly true where an acute need exists and can potentially help elevate the level of expertise for the betterment of healthcare delivery and human health. Furthermore, as described above, the educational technologies that exist for content translation and deployment are favourable to focused interactions with U.S.-based informatics programs. By accessing and building upon the resources described in this chapter, the informatics instructional materials, educational multimedia, learning objects, and published informatics literature all available in the public domain, there is promise for the translation of informatics programs on a global scale.

Key Take-Away Points

- Informatics capacity-building efforts outside the U.S. benefit from strong collaborations with academic institutions and leaders in the targeted region.
- The benefits of collaborations between U.S. and the non-U.S. institutions are mutual—many successful programs outside the U.S. can provide models for large scale informatics education programs.
- Information and communication technologies offer numerous ways to disseminate informatics educational content effectively.
- Language and infrastructure differences can present challenges in translating U.S. – developed programs to other countries.
- Translating informatics educational content to countries and regions outside the U.S. requires sensitivity to organizational, cultural, and social context.

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Chapter 14
Informatics Education in Low-Resource Settings

Paula D. Otero, Caroline Perrin, Antoine Geissbuhler, Ngai-Tseung Cheung, Nawanan Theera-Ampornpunt, and Kwok Chan Lun

Abstract Developing countries have the burden of acute and chronic diseases with the greatest health disparities. There is also a shortfall of more than four million healthcare workers worldwide, and the proportion is higher in less economically viable countries where the lack of proper trained healthcare workers is also compromised by the migration and departure of skilled personnel together with a frail infrastructure and a shortage of resources that cannot provide a proper scenario for an adequate healthcare system that will fulfill the population needs. The need for both technology infrastructure and individuals who have the skills to develop these systems is great,

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_14,

but so are the challenges in developing the needed workforce who are well-trained in informatics. This chapter describes the current informatics education efforts in three regions: Latin America, Sub-Saharan Africa and the Asia-Pacific region. The description of specific healthcare informatics education programs, the educational methods used and the challenges encountered are explored.

Developing countries have the burden of acute and chronic diseases with the greatest health disparities. There is also a shortfall of more than four million healthcare workers worldwide, and the proportion is higher in less economically viable countries where the lack of proper trained healthcare workers is also compromised by the migration and departure of skilled personnel together with a frail infrastructure and a shortage of resources that cannot provide a proper scenario for an adequate healthcare system that will fulfill the population needs [1].

e-Health has been defined by the World Health Organization as a broad term for the combined use in the healthcare sector of electronic information and communication technology for clinical, educational, research and administrative purposes, both at the local site and at a distance [2].

Capacity building has been defined by the United Nations Development Program as "the creation of an enabling environment with appropriate policy and legal frameworks, institutional development, including community participation, human resources development and strengthening of managerial systems" [3].

e-Health applications can be of great use in building capacity in countries by making a bridge between what is known in healthcare and how to translate it to the proper care not only at an individual level but also in healthcare institutions. In order to implement effective e-Health systems that can achieve national and regional healthcare goals that reduce the burden of acute and chronic diseases there is a need for solid pillars that will assure the persistence of the systems over time. This ambitious endeavor requires leadership and a properly trained workforce that can focus on projects that will have successful completion [2].

e-Health applications and health information systems have been shown to benefit healthcare in developed countries. Although the health disparities are a challenge for proper access of the population to healthcare in developing countries, a recent systematic review on evaluations of e-Health implementations in developing countries showed that the availability of systems that made healthcare institutions interoperable and provided monitoring of the medication cycle from ordering to patients' compliance were also successful [4].

As we mentioned before, one of the challenges to implementing e-Health is the lack of a well-trained professional workforce that can design, initiate, implement and lead projects. This workforce needs to understand healthcare, information and communication technology, as well as the organizational challenges involved in the implementation of e-Health.

Health informatics is the scientific discipline that provides the basics for e-Health since it applies information using information and communication technologies to help improve individual health, healthcare and public health. Health informatics education has been available worldwide for several decades, mainly in developed countries. In the last 15 years there are scattered educational initiatives in developing countries. The lack of a biomedical informatics education and research infrastructure in the developing economies still remains as a major barrier both to the development of health informatics as a discipline and to the sustainability of the implemented e-Health solutions [1, 5, 6].

In 2008 the Rockefeller Foundation hosted a conference called “Making the e-Health Connection: Global Partnerships, Local Solutions”, that gathered experts to help in the definition a new agenda to expand globally the use of e-Health. The chapter on capacity building that is part of the Report “From Silos to Systems” defined a vision that included three objectives [1]:

- Create an international network of e-Health informatics practice, education, training, policy and research;
- Educate government leaders about the importance of e-Health capacity and informatics to national health and economic development goals, cultivating and sustaining support for e-Health capacity and informatics activities;
- Develop a blueprint for initiating and executing activities in resource poor countries to rapidly create e-Health initiatives.

There have been different educational initiatives in Health Informatics that have been successful in developing countries. In this chapter we will describe the different experiences in health informatics education in three regions that include developing countries: Sub Saharan Africa, Latin America and Asia-Pacific. We will illustrate lessons that may have applicability to other countries that are trying to develop informatics programs.

Sub-Saharan Africa

Sub-Saharan Africa has a disproportionate burden of disease and an extreme shortage of health workers [7] as it “… has 24 % of the burden (of diseases) but only 3 % of health workers commanding less than 1 % of world health expenditure. The exodus of skilled professionals in the midst of so much unmet health need places Africa at the epicenter of the global health workforce crisis” [8]. In order to fulfill a minimum requirement of 23 health professionals per 100,000 people, an estimated 820,000 supplementary health workers are required in Sub-Saharan Africa [8]. The healthcare systems are challenged by increasing cost of care and suffer from fragmentation, weak information systems, lack of good governance, financial constraints [9] and a deficit of trained human resources. Furthermore, educational inequality is widely recognized as a factor impairing the development of a country [10, 11] and negatively influencing GDP growth.

Even though strong evidence is still lacking, information and communication technologies (ICTs) have the potential to provide innovative approaches for alleviating these problems, as ICT can help to overcome geographical barriers, increase access to healthcare services, train healthcare professionals through distance education and provide the possibility of collaborative healthcare in remote locations.

The Global Observatory for e-Health, conducted a survey on e-Health activities in 112 countries in 2009 [12, 13], which showed that, even though there is a substantial implemented number of telemedical solutions most of them remain either in the pilot or informal stage of development and are not institutionalized.

In Africa, e-Health is considered a possible solution for the previously described challenges, but there are few people trained in e-Health [7]. Very few postgraduate telemedicine-training programs are established internationally and only one is in Africa [14]. The International Medical Informatics Association (IMIA) Working Group on "Health Informatics for Development" recognized the need for training manpower in developing countries in medical informatics as early as their first meeting in 1983, and emphasized the importance of health informatics in the African continent at their first international conference on Health Informatics in Africa (HELINA) in 1993 [15]. Considering advancements in technology and their application in the health sector in Africa it is essential to understand that "technology gives us tools, but it does not provide us with the wisdom and the skill to use them [16]". To be able to use these tools and to achieve a sustainable development, which depends on a skilled workforce to implement, use, support and maintain e-Health [7], establishing programs, and training human resources in the domain of e-Health in Africa is essential [16–19]. This requires opportunities for informatics training, university partnerships and development of human resources covering all sectors of e-Health [1, 7]. Health informatics education can be implemented as an educational program for supporting healthcare professionals, who need this training to manage health data and information in their job, or as educational programs to support an e-Health strategy that aims to train experts that can plan, deploy and assess e-Health applications [9].

Health Informatics Education Programs in Sub-Saharan Africa

Several health informatics education programs have been established in Sub-Saharan Africa, mostly in South and East Africa.

Walter Sisulu and Winchester University Program (CHIRAD in South Africa)

The Walter Sisulu University offers, in conjunction with Winchester University in England, coursework for a Masters in Health Informatics. The emphasis of this program is for students to "learn the necessary knowledge, skills and understanding of the personal behaviors needed to identify the opportunities and drivers for change, select the appropriate information and communication technologies, involve perceived beneficiaries, identify the prospective benefits and successfully plan, implement and evaluate the impact of change." The qualification is yet to be registered and accredited by the South African authorities [20].

The Regional East African Center for Health Informatics (REACH-Informatics)

REACH-Informatics in Kenya recently established in collaboration with the Indiana and Moi Universities Schools of Medicine and the global informatics leadership of the Regenstrief Institute, a two-year medical informatics post-doctoral fellowship program with the aim of training fellows to implement and use health information technology to enhance research and improve healthcare quality, efficiency, and outcomes [21].

Masters of Health Informatics in Rwanda

The Regional e-Health Center of Excellence (REHCE) is hosted by the Kigali Health Institute (KHI) [22], which is a public higher learning institution established by the government of Rwanda in 1996. The KHI is committed to be a centre of excellence in training and development of health professionals and to train and improve the capacity of health workers. The REHCE offers a Master of Science in Health Informatics that aims at training highly competent health personnel in health informatics; providing in-service short courses for continuous professional development; introducing e-Health technologies in all medical and health curricula; assisting in e-learning health programs in Rwanda; collaborating with the National University of Rwanda (NUR), schools of public health, teaching hospitals and other reference hospitals in telehealth implementation; conducting health research in health informatics; and developing new training programs in e-Health.

The Nelson R. Mandela School of Medicine Telehealth Department

The Nelson R. Mandela School of Medicine (NRMSM) created an academic department of telehealth in 2002, aimed at establishing and running postgraduate academic programs in both medical informatics and telemedicine, facilitating e-learning within the medical school, assisting the Department of Health (DOH) in establishing and running telemedicine programs and conducting international outreach through e-Health [7].

Applied Projects Leading to the Creation of Centers of Excellence in Low–Resource Settings

For a health informatics program in Africa to be successful it is necessary to incorporate the local context. It is not sufficient to just re-produce an existing course or program, but it needs to be adapted to the local needs, context and culture. In French-speaking Africa, health informatics education results from the deployment of applied projects in e-Health, telemedicine or public health. These projects create a demand for local skilled professionals, thus generating enough activity and momentum to enable the creation of dedicated structures for training, education, and research. Eventually, these centers of expertise will be included in universities.

Réseau en Afrique Francophone pour la Télémédecine (RAFT) and the Jinou Program

The RAFT network [23], launched in 2001, primarily aims at de-isolating healthcare professionals that work in remote settings, through distance education and access to tele-expertise. Active in 18 Sub-Saharan African countries and more than 150 hospitals, and based on a predominantly South-South collaboration scheme (i.e., collaboration among developing countries), its scope has been extended to include the training of medical specialists in various fields, including medical informatics.

This extension, the RAFT–Jinou program, is based on the continent-wide sharing of expertise in various medical specialties: professors from French-speaking universities will each contribute by teaching a number of e-courses, which are organized in a structured curriculum for each specialty. The courses are taught with support from the RAFT infrastructure and tools. The RAFT-Jinou model has demonstrated that scarce human resources can collectively build capacity in a collaborative training approach, and serves as an inspiration for the development of a geographically-distributed Master in Health Informatics in French speaking Africa, promoted by a professionals in Cameroon, Mali, Burkina Faso, Niger, and Guinea.

Centre d'Expertise et de Recherche en Télémédecine et E-santé (CERTES)

Initially developed in collaboration with the RAFT network, the Malian Medical Information and Communication Network (REIMICOM) established CERTES in Mali after 10 years of applied projects development. Staffed with a dozen healthcare and IT professionals, the CERTES is in charge of training healthcare professionals to use health IT tools, to provide operational support for telemedicine activities and health information systems deployment, and to run research projects financed by competitive funds. Strongly linked with the Department of Public Health at Bamako University, it will contribute to the creation of a health informatics master's program and graduated its first group of MD students in 2012. CERTES is a good example of a bottom-up approach at developing a critical mass of Health Informatics activities, which in turn helps to organize and support a formal training program.

Multilateral Capacity Building

The Health Informatics Building Blocks (HIBBs) Project

As described in Chap. 13, The American Medical Informatics Association (AMIA) created the HIBBs project with initial funding from the Rockefeller Foundation as part of its Global Health Informatics Partnership (GHIP) [24]. The goals of this project are to coordinate and provide distance learning and education in informatics and to collect, create, test and deploy appropriate informatics training content. The open-source content is delivered in a modular approach, can be used alone or as part of a larger curriculum, and provides knowledge and skills on health information use and management. The HIBBs modules have been designed to be portable, reusable, and adaptable to local needs.

AFRICA BUILD

AFRICA BUILD [25] is an EU-funded project (2011–2014) aspiring to improve capacity for health research and education in Africa with the main objective to promote health research, education and practice in Africa. This is expected to be achieved through the creation of centers of excellence, by using IT, e-learning and knowledge sharing through Web-enabled virtual communities. The project includes a custom-designed collaborative platform to foster education, training and knowledge sharing between virtual communities of African researchers. The action is expected to promote African health scientists along with their institutions, and research networks, in order to create a sustainable and attractive research landscape for health research in Africa, but also aims at building capacity for medical informatics. The African participants are strongly integrated in the development of the platform and tools, and some of the courses taught are in the field of medical informatics.

The International Society for Telemedicine and e-Health's (ISfTeH) Basic Telemedicine Training Program

The ISfTeH [26] developed a basic, modular and adaptable course in Telemedicine that is delivered face to face. The curriculum covers introduction to computers; ethics and law in telemedicine; setting up venues; basic telemedicine skills; basic skills in the use of email and digital photography; practical use of store and forward telemedicine; teleeducation; and telemedicine and homecare. The training program was taught in 2009 to groups of physicians in several hospitals, and has been modified afterwards based on the participants' feedback [14].

Challenges Ahead

These examples illustrate the potential benefits of e-Health, but to develop its full potential strategic commitment, organizational changes and a harmonization of activities in e-Health, telemedicine and implementation are required on a national level with specific attention to the education of medical informatics professionals, as they are the basic foundation for the successful implementation and development of any e-Health project. Two groups of medical informatics professionals need to be qualified: healthcare professionals that are trained using e-Health applications and tools, and professionals that are able to support and carry out e-Health projects, and develop tools. The survey of the Global Observatory for e-Health [27] concluded that many African countries do not have a national e-Health strategy, yet an increasing number of countries in Africa are establishing a national e-Health strategy. The e-Health Strategy Toolkit, which has been developed by the WHO and the International Telecommunications Union (ITU) [28] is expected to accelerate this development. Furthermore the African Union is highlighting the need to harmonize telemedicine and e-Health activities in Africa [7].

The potential of low-cost wireless telecommunication access technologies for health education, ICT enabled care processes, public health activities, business and community development in Africa is emphasized by the ITU and others [29–32]. In the absence of fixed line networks and hardware, infrastructure challenges remain important, consequently mobile phones and related technologies like the General Packet Radio Service (GPRS) and wireless technologies are expected to be increasingly used for accessing the Internet [29].

There is no single e-Health solution that fits all. For e-Health to develop its full potential in Africa, solutions and applications have to be developed and deployed based on real needs, fostering innovative ideas and combinations of existing and new technologies. Capacity should be developed at different scales and across all sectors of e-Health, moving from vertical silos to widely-connected systems, by facilitating the evolution and development of infrastructure for existing centers of excellence, and establishing North–South (between developed and developing countries) as well as South-South collaborative networks of excellence [1], based on models of successful implementations [33].

Latin America

There are 21 countries that vary greatly in size, wealth and population that form the Latin American región. In what follows, this grouping of countries was done according to the sharing of a common language (mainly Spanish, Portuguese and French).

Latin America is widely known as the world's top unequal region. The public health challenges the region faces are due to the acute socioeconomic inequalities, along with gender, racial, and sexual discrimination, and the world's highest income disparities. It has been said about the region that 35 % of the region's population lives in poverty, and 21 % of the residents do not have access to healthcare services [34].

Also the current healthcare challenges that the Latin American states face are the growing burden of non-communicable chronic diseases which the Pan American Health Organization (PAHO) reported had become the "greatest cause of premature death and morbidity in Latin America and the Caribbean". In addition, infectious diseases continue to cause death in the region, and outbreaks of dengue and yellow fever are on the rise [34–37].

In the region healthcare is underfinanced leading to deficiencies mainly in basic care that should be granted to all the population. It has also been described as having an inefficient allocation of the limited resources available and there is no proper coordination between all the stakeholders, leading to effort duplication and resource wastage. The current situation needs to be addressed in order to provide equity in the provision of healthcare services with efficient management and perceived quality by the population [38].

Inequalities persist in the access to healthcare services due to different causes that challenge the possibility of getting timely and high quality healthcare when needed. Among the different factors that compromise proper healthcare are the lack of qualified human resources and proper infrastructure, together with lack of technology, equipment and drugs due to the low income situation that many areas of the region face. Since there are limited financial resources to support healthcare, qualified healthcare professionals seek work opportunities in urban areas within the country leading to a concentration of the most highly trained health personnel in urban areas or abroad. There is also a severe shortage of nurses in many countries (on average less than five nurses/10,000 pop) [35, 39].

Given the challenges facing the healthcare sector in the region, e-Health should have great potential for Latin America. e-Health could propel and lead to a more equitable, effective and efficient way to improve access, provide timely care and help in cost reduction to ensure more effective diagnosis and treatment. WHO's second global e-Health survey was completed by some countries of the Latin American region. The main results show that 45 % of the respondents had an e-Health strategy together with 36 % having a telemedicine policy. Eighty-two percent (82 %) also declared that they were investing in IT and software; including pilot projects in e-Health and 63 % in digital literacy for the proper use of these technologies. eLearning initiatives were used as a teaching tool for healthcare by 82 % of the respondents while 91 % acknowledged using distance learning to train health professionals. PAHO also conducted a recent study to determine the existence of e-Health initiatives in the Americas region. The survey showed that 68 % of 19 members considered e-Health a priority on their national agendas, while 47 % indicated having policies or strategies for the use of ICTs within the health sector [40, 41].

Despite the results of the survey, e-Health initiatives, both public and private, have been small-scale projects that were not properly included in public health and e-Health strategies. However the use of IT in the health sector continues to grow and is slowly driving changes in the way the population interacts with healthcare.

PAHO has developed an e-Health Strategy and Plan of Action (2012–2017) that aims to help the sustainable development of the Latin American countries' healthcare systems [41]. e-Health will be a means of improving healthcare access and quality, based on the use of IT, the development of digital literacy together with access to the scientific literature. This strategy will help health information access that is considered a basic right of the people to be informed and to have equitable access to healthcare. The strategy addresses different topics related to e-Health such as electronic health records, telemedicine, mobile health and interoperability, but specifically regarding education the Strategic Area 4 refers to knowledge management, digital literacy, and education in information and communication technologies as key elements for ensuring the quality of care, health promotion, and disease prevention activities, guaranteeing training and better access to information in an equitable manner. This has the potential to promote education activities in health informatics for the region [42, 43].

It is widely recognized that e-Health is a useful tool that can enhance the competencies of the healthcare workforce to support patient care, making well-trained professionals in this area of expertise a key need. Although there have been training programs in health informatics in developed countries for over 40 years, in the Latin American region only a few countries have developed initiatives for formal training in the discipline. These programs have included short courses, certificate and masters programs. QUIPU, The Andean Global Health Informatics Research and Training Center, surveyed 142 experts from 11 countries of the region (mainly from Perú) as to their needs for informatics training. The top ranked courses in a scale from 1 to 5 were related to medical informatics: introduction to biomedical informatics (score 4.41); data representation and databases (4.29); mobile health (4.26); and security, confidentiality and privacy (4.25). The research topics that were considered as a priority were: Evaluation of Health Information Systems; Policy in Health Informatics; Interoperability and Standards; Evidence-based Decision Making in Informatics; Rural Telemedicine; Mobile Health; Electronic Health Records; Sequence Analysis and Gene Finding; Tele-education; and Cost-effectiveness Analysis in Biomedical Informatics. These results could help to define the competencies and the structure of training programs for the region but as of the middle of 2013 there were no education programs that have addressed these results [44].

Health Informatics Education Programs in Latin America

Several health informatics education programs have been developed in the region; below some of the published experiences are described.

Argentina

Hospital Italiano de Buenos Aires Medical
Medical Informatics Residency Training Program
Spanish Version of AMIA's OHSU 10×10 Course

Hospital Italiano de Buenos Aires (HIBA) is a non-profit healthcare academic center founded in 1853, in 1998 HIBA decided to implement a Healthcare Information System (HIS) called "ITALICA" developed as an in-house project that currently handles all the information related to healthcare both clinical and administrative, from its capture to its analysis. As part of the project, the Department of Health Informatics was created in 2001, at the same time a postgraduate education program was created. The medical informatics residency is a 4-year program that has been accredited by the national authorities that aims to train physicians to be a major factor in e-Health and to work as a "bridge" between healthcare and IT. The training curriculum includes healthcare (two years in internal medicine), computer science, healthcare information systems, electronic health records management, epidemiology, knowledge-based databases for clinical terminology and standards, biostatistics and decision making theory. The graduates of the residency program are currently working on different e-Health projects in Argentina and Chile as Chief Medical Information Officers (CMIOs) at healthcare facilities coordinating development and implementation of health information systems and working at the health ministry level helping in the creation of a national e-Health agenda [45].

The Department of Health Informatics at Hospital Italiano also developed other courses for digital literacy oriented to information retrieval and computer literacy, and helped in the creation of an HL7 introductory course. A collaboration with Oregon Health & Science University's Department of Medical Informatics and Clinical Epidemiology allowed the regional adaptation of AMIA's 10 × 10 in 2006 (see Chap. 8 for additional detail). The initial course was a Spanish translation of the 10 one-week units. After the initial experience and feedback from the students, the course has been adapted to better meet regional needs (for example characteristics of healthcare in the region and public health informatics topics were added. Security and privacy issues such as HIPAA – the Health Insurance Portability and Accountability Act, are not addressed since HIPAA only applies in the U.S.). Currently it is entitled Introductory Course to Health Information Systems and has 15 modules that are delivered in 16 weeks with topics that address the needs of health informatics in the region. Through December 2012 more than 1,000 students have taken the course from all over Latin America, and more than 80 % (850 students) are active in the field of Health Informatics. This experience provided basic training for healthcare professionals in medical informatics in Latin America in their own language. The course has been well-accepted by users across the region. This could represent a model for disseminating knowledge of medical informatics across other languages and cultures [45, 46].

Brazil

Open University of the Unified Health System Health Informatics Education

In Brazil the Open University of the Unified Health System was launched as an e-learning endeavor in the context of the National Telehealth Program. This project mainly promotes the production of distance healthcare courses for the country so that healthcare professionals in many states experience the potential of new teaching technologies that include web conferences and courses that use simulators, organic modeling and animations as part of the training experience.

The Ministry of Health has supported the production of didactic material within the program, which addresses the ongoing training and education needs of healthcare employees working in the area of health, offering distance postgraduate and university extension courses to professionals. It also has a public collection of educational materials that are available free of charge on the Web [47].

In Brazil, education in nursing informatics was the first focus for informatics training. It was promoted by the development of nursing education programs with nursing informatics topics in the curriculum.

A program financed by the Fogarty International Center started in 1999 and funded the creation of 10 onsite health informatics courses in Brazil, which were subsequently made available on the Internet and CD-ROM, together with regular medical informatics courses taught yearly in the U.S. at Harvard University initially and currently taught in conjunction with the University of California San Diego. Several regions of Brazil were reached during the development and implementation of this training program and by 2003 over 1,700 healthcare professionals were trained. The program has continued and currently training is provided to all healthcare personnel. Different courses were added to the offering such as: Introduction to health informatics; computer-aided instruction; electronic medical records; clinical systems; telecommunications and network infrastructures to support healthcare, homecare, biosignals, and images in medicine; hospital information systems; and decision support systems. This program has the potential to be expanded since an important project entitled RUTE (Red Universitaria de Telemedicina – University Network of Telemedicine), is being coordinated by the National Network of Teaching and Research. The National Program of Telehealth Care currently integrates academic teaching institutions with nearly 60 healthcare facilities and hundreds of primary care clinics throughout the country promoting improved access to healthcare, health information and training for individuals that live in regions that are remote and difficult to reach. In 2006 it started with 19 university hospitals and currently 158 institutions have benefited by RUTE and nearly 400 health institutions are involved in online virtual events [48, 49].

Currently the Brazilian Society of Health Informatics is working on the development of proTICS – Professionalization Program in Information Technology and Communication in Health – that aims to promote and encourage the creation of new undergraduate and postgraduate courses in health informatics and also will collaborate with the definition of the minimum content and quality criteria so that the accreditation of this course occurs in proTICS, thus obtaining official recognition from the national academic society.

Chile

In Chile Health Informatics training initiatives are diverse and have been motivated by the need to implement e-Health projects in different settings.

Since 2011 the Heidelberg Center for Latin America together with the School of Medicine of Universidad de Chile have developed a collaborative Masters in Biomedical Informatics. This program has two specializations: the first will focus on health informatics, with an emphasis on health information management, and the second will focus on bioinformatics and biomedical image processing, with emphasis on information processing and complex computational and statistical techniques.

The Center for Health Informatics of the Universidad Central de Chile also offers graduate certificate programs on Medical and Nursing Informatics, Standards, Evidence and Decision Making in Public Health and Project Management in Health Informatics. At a tertiary non-university level, a technical program of undergraduate training in biomedical informatics has been created at the Professional Institute and Technical Training Center DuocUC. It is a four-year program and the graduates become Biomedical Informatics Technologists. This offering is quite innovative since most of the programs in the region only focus on healthcare professionals.

Colombia

Health Informatics in the Universidad de Antioquia, Universidad de Cauca and Universidad Javeriana

The Universidad de Antioquia has a Master of Biomedical Sciences with emphasis in medical informatics, which is currently offered exclusively to health professionals. The program includes in its curriculum introduction to health informatics, telemedicine, knowledge representation, and user interfaces design for e-Health. The University also has a graduate certificate program in medical informatics in collaboration with the Center for Health Sciences at the University of Texas in Houston.

The University of Cauca educational offering consists of a MSc and PhD program in Telematics Engineering, both of which have an area of research in e-Health. This program is offered exclusively to engineering professionals, and is developed in collaboration with e-Health Competence Center Regensburg in Germany, which has a department that is responsible for basic and domain-related research, education and other academic obligations in the telehealth field. The Universidad Javeriana and Pittsburgh University have received funding to develop the ENRICH project: "Enhancing Research and Informatics Capacity for Health Information in Colombia" This project aims to build capacity in health informatics with an emphasis on clinical research. The University of Pittsburgh will help in the creation of an integrated program to train researchers in health informatics and advanced research methods that will address the healthcare needs of Colombia. Different courses will be delivered locally in the form of workshops/seminars on clinical information systems, clinical terminologies, bioinformatics, database management bio-surveillance and clinical research methodology [50, 51].

Cuba

In Cuba there has been local development and implementation of e-Health projects but there has not been enough evidence published in the scientific literature to determine the details. The government created a Telematic Network for Health in Cuba, known as INFOMED that coordinates most of the projects which have mainly been used to deliver training activities through e-learning [52].

Mexico

Most of the formal training in health informatics in Mexico is at the undergraduate level. The School of Medicine at the Universidad Nacional Autonoma de Mexico is one of the largest medical schools in Latin America, with more than 7,000 undergraduate students and was created in the sixteenth century.

The undergraduate program underwent a major revision in 2008 and health informatics courses were added as core requirements in 2011. A Department of Biomedical Informatics was created and two one-semester courses were developed and delivered in a blended learning mode. The courses include basic health informatics content areas such as medical databases, electronic health records, telemedicine, medical decision-making and clinical reasoning. Nearly 1,200 students took the courses and evaluated the program positively [53].

Other universities also have undergraduate courses on biomedical informatics at their School of Medicine at Universidad de Veracruz, Universidad La Salle University, Universidad Panamericana and Universidad Anahuac. The Instituto Politécnico Nacional that provides training in engineering disciplines also delivers a health informatics course as part of their Biomedical Engineering program at the Unidad Profesional Interdisciplinaria de Biotecnología.

Perú

AMAUTA Global Training in Health Informatics
QUIPU Andean Global Health Informatics Research and Training Center
AMAUTA is a Quechua word that describes a person of great wisdom, one who knows and who teaches. The AMAUTA Global Training in Health Informatics program was developed in 1999 between two Peruvian and a U.S. university (Universidad Peruana Cayetano Heredia, University of San Marcos of Peru and the University of Washington) to train Peruvian healthcare professionals in health informatics. The program consisted of training individuals and providing the initial steps to develop a local training program. The collaboration developed short course offerings locally to identify needs and collaborators and potential trainees. There was also the possibility of postgraduate training in informatics for the local universities' faculty. The program has increased the availability of health informatics applications, knowledge about data collection methods, access to scientific resources, and geographic information systems for monitoring disease incidence and outbreaks, and bioinformatics training [50, 54].

Universidad Peruana Cayetano Heredia also received funding in 2009 to develop a health informatics training project entitled QUIPU (which means knot in Quechua, and is an ancient system used by the Incas in the Andes to record and distribute information). The objective of QUIPU is to promote research and training for biomedical informatics professionals and global health. QUIPU seeks to become a Center of Excellence of the highest quality in the Andean region by developing and implementing opportunities for biomedical informatics training, short and long term, in the Andean region. It will engage new researchers in the Andean region for research in health informatics and promote the expansion of a research network in the Andean region, promoting South-South cooperation and partnering with universities in developed countries [55].

Uruguay

In Uruguay the training in health informatics was initiated at the postgraduate level for the Federación Médica del Interior (FEMI). The intent was to start a health information system project that aimed to exchange and analyze clinical and administrative information at a national level. Twenty-three healthcare institutions across the country form FEMI, together with a tertiary referral center in the capital city of Montevideo. FEMI provides healthcare services to over 650,000 people nationwide (approximately 20 % of the population). The strategy was to train an interdisciplinary group at each of the institutions that would include a physician, who would act as Chief Medical Officer, an information system professional and a medical records technician. A total of 128 professionals were trained through online and in person sessions in Uruguay and Argentina, the topics addressed were health informatics project management, electronic medical record systems, human error prevention through system redesign, coding systems, health information standards, and data warehouses [56].

Recommendations for Addressing the Challenges

The World Health Organization has stated that in this century healthcare expectations need to be met through improved access to high quality resources for most of the world's population [57]. And there is also a strong recommendation at the regional level by PAHO to use e-Health as a strategic tool in the planning and development of healthcare actions [41].

The development of e-Learning modalities can help to address these recommendations by providing communication, knowledge acquisition, and access to knowledge to any person, in any place and at any time. e-Learning can help as an educational approach for large numbers of trainees since it can respond efficiently to the current needs for high quality universal education, and it is a suitable and viable resource for keeping people informed of the most up-to-date knowledge in healthcare and health informatics [47].

We have seen that many training projects were developed through cooperation between developed and less-developed countries. The most difficult and limited resource is local trained experts and a workforce that has skills in the development and implementation of e-Health applications. This situation is worse in developing economies that rely on foreign personnel who are available for a limited time, while a constant and local presence is needed so that these projects can evolve and narrow the "digital divide" by building e-Health training programs that address these local needs. To develop these partnerships there are different areas that need to be evaluated prior to a formal cooperation agreement: priority assessment, technology evaluation and selection criteria, implementation issues, emerging technologies linking patients and providers, access to knowledge databases, consumer health informatics. In developing countries, capacity building in health informatics can be used to address capacity shortages, by providing electronic information and training, especially in rural and underserved areas. There is a need for robust clinical data to address local healthcare needs, which are different from those in developed countries, due to cultural differences, political and economic factors, etc. Although the burden of chronic diseases is similar to developed economies, infectious diseases and malnutrition are still great public health challenges. These issues make it essential to find local solutions.

Individual capacities of the local workforce need to be evaluated and these capacities can be strengthened if the workforce profiles of future leaders of e-Health projects are correctly identified, if the size and composition of the workforce needed is determined according to the local needs and the current perspectives are taken into account such as language, the healthcare system and available resources. The training should be oriented to e-Health projects that can strengthen health as shown by the benefits achieved after a successful implementation of the project. In order to promote successful projects they need to be clearly stated and described in sufficient detail. The planners also need to expand their vision beyond the local involvement to all the future or current stakeholders from the managerial and operational areas. The PAHO e-Health Strategy and Plan of Action launched in 2012 has been adopted by most of the countries of the region so we hope that in a near future training programs will emerge that address capacity building as part of incorporating e-Health into all of the Latin American countries [5, 38].

Asia-Pacific

For this discussion the Asia-Pacific is defined as the group of countries along the eastern Pacific rim, including most of what is often called East Asia, Southeast Asia and Australasia.

The Asia-Pacific includes a heterogeneous group of countries that covers a great swath of territory and encompasses a massive population. The group members frequently have little in common other than geography. The region is highly diverse in almost all aspects, including racially, culturally, and economically as well as in religion, governance and healthcare systems. This wide diversity makes it extremely difficult to try to describe succinctly any aspect of this region, and certainly the area of health informatics development is no different.

Some of the more developed countries and territories in the region, such as Australia, Hong Kong, Japan, Korea, New Zealand, Singapore and Taiwan already have a long history of significant health informatics development. Australia launched the Personally Controlled Electronic Health Records system in 2012 as a national electronic records sharing system [58]. Hong Kong deployed the Clinical Management System, an interoperable EMR for all the 41 public hospitals and 121 associated clinics in Hong Kong [59] and is currently developing an electronic health record program for the whole of Hong Kong [60].

A recent study in Korea found 100 % adoption of CPOE at tertiary hospitals and a 77 % adoption of EMRs [61]. In Japan more than 62 % of major hospitals have an electronic medical record installed [62]. New Zealand is well known for the high rate of EMR adoption, particularly in the primary care sector [63]. Singapore launched the first phase of the National Electronic Health Record (NEHR) in 2011 to consolidate health records between various sectors of care [64]. In Taiwan the "Taiwan Electronic Medical Record Template" (TMT) interoperability standard has been developed to form the basis of the future National Healthcare Information Project (NHIP) [65, 66].

For these more experienced nations, Health Informatics and e-Health development is already firmly on the policy agenda. However even for the other countries in the region health informatics and health IT are seen as strategic imperatives to enable more effective, efficient delivery of better quality healthcare to their populations, and countries such as China, Malaysia and Thailand have also made significant strides in their e-Health journeys.

Health Informatics Education Programs in Asia-Pacific

This brief discussion will not attempt to provide a comprehensive review of all the health informatics education programs in Asia-Pacific. Instead we will try to illustrate the situation through three case studies.

Hong Kong

Hong Kong has taken a somewhat non-traditional approach to Health Informatics education. The Hong Kong Polytechnic University has a Department of Health Technology and Informatics, specializing in Medical Laboratory Science and Medical Imaging, which represents the only dedicated tertiary department teaching Health Informatics related material. More general health informatics education programs have been offered, such as the Postgraduate Diploma in e-Health Informatics taught by the University of Hong Kong School of Professional and Continuing Education, and the "Applied Clinical Informatics" distance learning course which is a collaborative venture between the Hong Kong Society for Medical Informatics, the Hong Kong Polytechnic University and is being recognized as an i10 × 10 course (the international variation of the AMIA 10 × 10 program).

The bulk of health informatics education in Hong Kong, however, has been provided as in-service training through positions in the health informatics Team and Information Technology Services in the Hospital Authority. The development of the Clinical Management System (CMS) and its deployment to all the public hospitals and associated clinics in Hong Kong has offered a unique opportunity to participate in the development and deployment of a very large scale electronic medical records system. Since the CMS was (and continues to be) entirely developed in-house, team members are exposed to a very wide range of health informatics disciplines, from strategic planning to deployment issues, from information architecture to usability, from clinical engagement to technical development. As the Hospital Authority has also been appointed the technical agency for the development of the electronic health record sharing system (eHR) for the whole of Hong Kong, members of the team have also been exposed to issues involved in interoperability and development for and deployment to different sectors of the healthcare system.

This sustained investment in development programs has resulted in a large number of experienced workers in the health informatics industry in Hong Kong and it is anticipated that the demand for such a workforce will increase in the future as the scope of health IT gradually increases and the eHR is deployed to all healthcare sectors.

Singapore

In Singapore, health informatics education falls into two categories – academic and certificate courses.

Academic Course. Since January 2012, health informatics has been offered as an undergraduate module (Course Code IS3250) at the National University of Singapore (NUS). The module runs for one academic semester and comprises 10 weekly lectures each of 90-minutes duration, followed by a 45-minutes forum at which industry speakers are invited to share their "ground experience" with the students. For example, after the lecture on Electronic Medical Records, the forum will feature a speaker from the Singapore Ministry of Health to update students on Singapore's National Electronic Health Record (NEHR) system which was launched in June 2011. Topics include (1) Overview of Health Informatics, (2) Information Systems in Healthcare Enterprises, (3) Computerized Medical Records, (4) Clinical Decision Support, (5) Standards and Interoperability, (6) Confidentiality, Privacy and Security, (7) Infocommunication Advances in Patient Care, (8) Bioinformatics – Biology meets IT, (9) Healthcare Analytics and (10) Pervasive Computing in Healthcare. As a requirement for passing the course, students have to undertake a course project. The final examination of the module comprises three sections – Section I with 20 multiple-choice questions, Section II with 10 short-answer questions and Section III with 1 essay question. Since it was offered in January 2012, IS3250 has been well-subscribed by students with an enrollment of about 60 students for each of its two runs.

Certificate Courses. Singapore also offers the international version of the AMIA-OHSU 10×10 Course through a collaboration between Gateway Consulting, the

American Medical Informatics Association (AMIA) and Oregon Health & Science University (OHSU), USA which started in 2009. The course is the same as the AMIA 10 × 10 course in the USA with lectures delivered from OHSU via distance-learning. In addition, students are required to participate in the online forums and undertake a Course Project to partially fulfill the course requirements. The course ends with a three-hour, open-book, invigilated examination. Known in Asia as the Gateway to Health Informatics (G2HI) Course, this international version of the AMIA-OHSU i10 × 10 course has just completed its seventh run and has, so far, trained some 160 healthcare and IT professionals from Singapore, Malaysia, Thailand, the Philippines, Brunei, Vietnam and Saudi Arabia. The course is endorsed by the Infocommunications Authority of Singapore (IDA) under its Hybrid Skills Development Program (HSP). Details of the Gateway to Health Informatics Course are available from http://www.gatewaypl.com/g2hi/index.htm [67].

In January 2012, the NUS Department of Information Systems established a Centre for Health Informatics (CHI) with co-funding from the Infocommunications Development Authority (IDA) of Singapore. A major term of reference for the CHI is to conduct executive training courses on various topics in health informatics for professionals in the healthcare and IT industries. These courses are generally 3-day, short courses comprising lectures, case studies and projects to equip course participants with knowledge and practical skills needed to respond to challenges of the workplace with ideas that are fresh, practical and relevant. Courses that have been offered by the CHI include Introduction to Health Informatics, Managing Healthcare IT Projects, Standards in Health Informatics, Databases in Healthcare Practice and Healthcare Analytics. More details on CHI Courses are available online [68].

Thailand

Formal education in informatics in Thailand can be classified into three levels: a certificate and diploma level, an undergraduate level, and a graduate level. At the certificate and diploma level, short courses in targeted areas of informatics are offered, often targeting individuals with specific roles such as the Chief Information Officers (CIOs) or Chief Medical Informatics Officers (CMIOs), or focusing on a particular field within informatics such as dental informatics. Table 14.1 describes the programs available.

Informatics education at the undergraduate level is mostly incorporated as part of other curricula, targeting undergraduate healthcare professional students, or ICT students with interests in healthcare and health IT. Medical records management and coding study which has been taught by an institute under the Ministry of Public Health as a vocational-level degree has extended to a four-year undergraduate degree. At the graduate level, master of science programs in biomedical and health informatics are offered by a few institutions, and there are also graduate programs in other related areas such as engineering, ICT, or dentistry with informatics-related research work. Table 14.1 lists some of the informatics academic programs in the country. There are also academic programs in bioinformatics offered in several institutions, forming the country's bioinformatics cluster with support from the National Center for Genetic Engineering and Biotechnology (BIOTEC).

Despite these educational activities, opportunities lie ahead for informatics education in Thailand. Strengthening the country's informatics education would require a standardized informatics curriculum with a recommended set of competencies that apply international recommendations to the local context. There is no

Table 14.1 Certificate, undergraduate, and graduate health informatics programs

Level	Program & institution	Notes
Certificate and diploma	ICD-10 Basic and Advanced Certificate Programs, Thai Medical Informatics Association	Targets medical coders and health information management professionals.
	Graduate Diploma Program in Biomedical and Health Informatics (International Program), Faculty of Tropical Medicine, Mahidol University	Targeting informatics practitioners, especially those who work in the area of public health.
	Healthcare CIO Certificate Program, Hospital Administration School, Faculty of Medicine Ramathibodi Hospital, Mahidol University	Targets Chief Informatics Officers (CIOs) or IT executives of healthcare organizations.
	Dental Informatics Certificate Program, Institute of Dentistry, Ministry of Public Health	Focusing on dental informatics.
Undergraduate	Bachelor of Science Program in Information and Communication Technology, Faculty of Information and Communication Technology, Mahidol University	First undergraduate ICT or computer science program with informatics contents.
	Doctor of Pharmacy Program in Health Informatics (Pharm.D.), Faculty of Pharmacy, Silpakorn University	Major in health informatics.
	Doctor of Pharmacy Program in Pharmaceutical Sciences (Pharm.D.), Faculty of Pharmaceutical Sciences, Chulalongkorn University.	Pharmacy informatics is a sub-major in the social and administrative pharmacy major.
	Bachelor of Public Health, Kanchanabhishek Institute of Medical and Public Health Technology, Ministry of Public Health	Focusing on health information management and medical coding.
	Bachelor of Nursing Program, Ramathibodi Nursing School, Faculty of Medicine Ramathibodi Hospital, Mahidol University	Nursing informatics a required course for undergraduate students.

Table 14.1 (continued)

Level	Program & institution	Notes
Graduate	Master of Science Program in Health Informatics, Institute of Health Science, Ramkhamhaeng University	First informatics graduate program in Thailand.
	Master of Science Program in Health Informatics (International Program), Faculty of Public Health, Mahidol University	Targeting informatics practitioners, biostatisticians, and data analysts.
	Master of Science Program in Biomedical and Health Informatics (International Program), Faculty of Tropical Medicine, Mahidol University	Targeting informatics practitioners and project managers, especially those who work in the area of public health.
	Master of Pharmacy Program in Health Informatics, Faculty of Pharmacy, Silpakorn University	Targeting pharmacy practitioners.
	Master of Science and Doctor of Philosophy Programs in Social and Administrative Pharmacy (International Program), Faculty of Pharmaceutical Sciences, Chulalongkorn University	Student research in informatics areas exist. Informatics courses available for students who aim to conduct research in informatics or related areas.
	Master of Engineering Program in Industrial Engineering, Faculty of Engineering, Mahidol University	Student research in informatics areas exist.
	Doctor of Philosophy Program in Oral Health Science, Faculty of Dentistry, Thammasat University	Student research in informatics areas exist.

informatics education at the doctoral level, and incorporation of informatics content in the education of health professionals varies greatly. Little local research in the area of informatics education exists. The push for a strengthened informatics workforce is necessary given the exponential growth in the application of informatics and health IT to healthcare. The Thai Medical Informatics Association (TMI) has recently established the Biomedical and Health Informatics Education Special Interest Group which hopes to address some of these issues in the years to come.

Lessons Learned and Future Challenges

All of the countries in the Asia-Pacific will face continued pressure on their healthcare systems resulting from demographic shifts, funding and manpower constraints, improvements in medical technologies and treatments and rising expectations from patients and their families. Health IT and health informatics are seen as key to helping meet some of these challenges but it is clear that the specific needs of healthcare delivery in the region and the resource constraints in many of the countries mean that local solutions will need to be developed. The Health Informatics education programs discussed above have demonstrated the ability of countries to build up local capacity in health informatics to enable the development of the necessary systems and programs.

There is no doubt that the demand for e-Health and m-Health will only rise throughout the region, and to meet this demand two areas must improve. Firstly, health informatics education programs in the region must be expanded and enhanced. Secondly, regional collaboration should be strengthened. Although the Asia-Pacific Association for Medical Informatics (APAMI) was formed in 1993 to promote health IT [69] more work needs to be done to share and disseminate the work that has already been done in the region to others, especially those countries that are just beginning to address the workforce needs.

Conclusion

Despite the documented benefits, there are still barriers to implement e-Health and one of the most important is the lack of a health IT workforce and the training programs needed to most effectively address the challenges. Although there are different initiatives in different regions and in different countries within the same region, there is still a need to focus on the role of e-Health, health informatics education and capacity building that is critical for improving healthcare quality and efficiency.

There are many opportunities in these regions that offer education in the discipline. In some countries, there are broad and complete dedicated educational programs in health informatics at different levels of education (undergraduate and postgraduate) and for the different healthcare professions (physicians and nurses) that offer specific career paths. In the regions, these programs co-exist with a myriad of offerings that may have some kind of degree, diploma or certificate. Still other countries have not developed successful programs illustrating the disparities in the health informatics training in each of the three regions.

We have reviewed the education experience in three regions that include developing economies, although these regions differ in culture and language they still share the same challenges in the implementation of e-Health. The lack of coordinated projects and "islands" of educational programs and training activities still remain as a barrier, although there is still a need for healthcare practice, education, training, policy and research carried out as a coordinated effort so lessons learned from other experiences worldwide can be leveraged in the efforts carried out locally. The possibility of collaborative partnerships between countries within the same region can improve training opportunities; such partnerships could also work between regions in spite of their cultural differences as globalization continues.

e-health applications are still a promise to improve global health in developing countries. A proper approach to implement e-Health should include needs assessment together with education and formal training opportunities for the healthcare and health informatics workforce. The local successful experiences could be extended into the region that would be able to scale for a rapid and effective way of dissemination. Such an approach could also promote the creation of academic partnerships and centers of excellence in education and research in developing countries for sustainable capacity building in health informatics.

Key Take-Away Points

- Partnering with existing informatics education programs from other nations such as the U.S. and Europe is a useful approach to start new informatics programs in regions with shortages of informatics educators.
- Programs from outside the region usually have to be adapted to address the local context.
- Educational programs, including informatics education, can often utilize existing telematics/telemedicine/telehealth infrastructure to reach sufficient numbers of participants to make the program viable.
- Collaboration within regions can be an effective way to disseminate successful programs that are tailored to the needs of the region.

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Part V
Summary of Lessons Learned

Chapter 15
Informatics Education in Healthcare: Lessons Learned

Eta S. Berner

Abstract This book provides a comprehensive description of informatics education programs in healthcare. It includes analysis and lessons from almost a 40-year history in the developed countries as well as newer programs that are expanding in less well-resourced areas. From an initial focus on the development of informatics researchers who would apply their informatics and computer science knowledge and skills to the healthcare domain, we have seen more and more programs being developed for healthcare administrators, practitioners and scientists who recognize that they need informatics expertise to function within their own domain. This chapter synthesizes the lessons that have been described throughout the book

Informatics education programs have been evolving over an almost 40-year span of time. Existing programs have changed over the years as new and different driving forces have influenced them. While some of the programs began with a few visionaries with expertise and interest in computer applications in healthcare, the current drivers for informatics education and manpower development are clearly the increased sophistication of technology, including electronic health records, distance learning technologies, and telemedicine applications as well as policies mandating their integration into healthcare delivery.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8_15,

The audience for informatics education has grown in a similar manner. From an initial focus on the development of informatics researchers who would apply their informatics and computer science knowledge and skills to the healthcare domain, we have seen more and more programs being developed for healthcare administrators, practitioners and scientists who recognize that they need informatics expertise to function within their own domain.

Despite the differences among the programs in terms of focus, students, and purpose, there are also many commonalities, but these may be more difficult to recognize as one reads each individual chapter. For that reason, this chapter synthesizes the lessons that have been described throughout the book using the following organizational framework:

- Evolution of Informatics Education Programs
- Informatics Competencies and Sources of Curriculum Materials
- Online Instructional Strategies
- Evaluation and Accreditation of Informatics Education Programs in Healthcare

These topics mirror the stages of individual program development including development and evolution of the overall program, identification of competencies and development of the curriculum, instructional strategies, and program evaluation methods.

Evolution of Informatics Education Programs

Informatics Education Programs in Europe and the U.S.

John Mantas identified phases that were encountered in the evolution of many of the European informatics programs. As Mantas described it, these phases include the initiation phase, when individual programs, led by a visionary leader, began and, because there were no models or examples, development of curricula was more or less a trial and error endeavor. As some of these early programs developed eventually there became more of a consensus on curricular guidelines and programs began to expand. As curricula became consolidated, in the last several years the need for evaluation of programs across sites and accreditation of individual programs was seen (John Mantas, PhD, personal communication, 2013).

In the U.S., since most of the early programs were funded with NIH funding from the NLM, the curricular content of many of the U.S. programs was largely responsive to what the NIH saw as key manpower needs, generally for sustaining the healthcare research enterprise. At first the NLM training programs as described in Chap. 3, since they were funded by the National **Library** of Medicine, were more heavily focused on librarian training, but as the field evolved to include more automated means of managing healthcare information in practice, they shifted more into the domain of clinical informatics research and development, where they remained until fairly recently when, with increasing growth of genomics research, the NLM programs also began to incorporate bioinformatics content and most recently public health informatics and the use of clinical applications in practice.

It was after the programs had been operational for quite awhile, that more formalized program evaluation criteria for the overall NLM program were developed, as well as better guidelines for individual programs that apply for NLM funding. These guidelines for individual programs that are included in the summary and key take-away points of Chap. 3 are useful guidelines for any informatics program development, not just those funded from a specific source. These points include making sure that the content draws from the variety of disciplines and domains that are either the underpinnings of the field or are application areas of informatics in healthcare. The curriculum should include key informatics concepts, methods and state-of-the art technology assessments and a variety of approaches should be employed to evaluate the program's success in meeting its goals.

The ONC workforce program described in Chap. 7 had some of the same visionary beginnings, but it was addressing a more applied need. With the rapid increase in the use of health information technology anticipated with the passing of the HITECH Act [1], it was envisioned that new workforce roles would be needed and, to prepare individuals for those roles, new training programs would be needed as well. The ONC workforce program was designed to meet the needs for new types of individuals who could support the growing health information technology developments.

In many ways, all of these programs were future-oriented. The NLM training programs began when nobody except the early developers was using clinical computing in healthcare. The ONC workforce programs began with envisioning new roles for a healthcare system that would become increasingly electronic, but was not there yet. Over the same time period that the NLM training programs evolved to include broader domains than just clinical informatics, electronic health records and clinical decision support systems, whose development was a focus of the early clinical informatics programs, began to be applied in healthcare.

Unlike the programs that envisioned new roles and new applications, the programs for managers of healthcare information systems (Chap. 6), informatics programs for healthcare administrators (Chap. 10), and certification programs for clinical informatics practitioners (Chap. 4) developed after individuals without formal informatics training had been in practice for a number of years. For instance, Chief Information Officers and healthcare administrators usually did not have formal training in informatics. More recently, with the increase in clinical computing, the role of Chief Medical Information Officer, or CMIO, has become prominent, but many of the individuals filling these roles have not had formal informatics training either.

The perceived need for more formal training on the part of the individuals already in these roles, as well as informatics educators recognizing the need for more formal educational programs, has spurred the development of many of the newer, more applied programs. These programs include entire degree programs like the health informatics masters programs (Chap. 6), nursing informatics masters programs (Chap. 5), health information systems courses within health administration programs (Chap. 10), and informatics continuing education programs, such as the AMIA 10×10 program described in Chap. 8 and mentioned in many of the other chapters.

In addition to the new educational programs, there has been a parallel recognition of the need to certify the competencies of individuals in these applied roles, and, as the educational programs have gotten established, there have also been efforts at program accreditation. The clinical informatics subspecialty certification and training programs described in Chap. 4 and similar programs for nursing informatics described in Chap. 5 are examples of these programs.

What is common to all of the formal programs that evolved after individuals without formal training had been in practice is that they all emphasize the need to look to competencies exemplified by the best of the those practitioners, as well as the more theoretical informatics concepts, to develop training curricula and certification content. These types of programs will also continue to evolve, as they should, as the workforce needs change. At this stage of the field of informatics, where the applications and principles are now beginning to be used in clinical practice, new program developers should be keenly aware of the market needs and should develop programs focusing on the competencies needed to thrive in that market.

Informatics Education Programs in Low Resource Areas

As described in Chaps. 13 and 14, the development of informatics programs in many of the developing countries evolved differently from either the early U.S. or European countries or the more applied programs where there were already practitioners in the field. First of all, in many of these low resource settings, telemedicine programs were initiated to address the regional healthcare needs for better access, better care, and the limitations of long distances and limited transportation that were prevalent in these countries. This telemedicine infrastructure required a workforce who could manage it, but in addition, the infrastructure could also be used not only for health education, but for health informatics education as well.

Thus, in part because these programs were started later than those in the more developed countries, many of the informatics programs in these countries began as online programs, unlike in the U.S. where online education occurred at a later stage of program evolution. Second, again because the other programs were already established and many were already providing online education (see Chap. 8), many of the programs in the developing countries began in partnership with the more established programs. In some cases, such as with the AMIA 10×10 programs, students from developing countries took the same program as those in the U.S., either in English or translated into the native language. In other cases, there was a partnership to develop a program that made use of materials originally developed in the U.S. or Europe, but which was tailored for the unique needs of the country. More recently, as discussed in Chap. 14, many of these programs evolved to more independent programs and there is increased sharing of expertise and curricula within regions, rather than only between the more developed and developing countries.

While there are certainly benefits in developing new programs by partnering with more mature programs there are also challenges. Both those who are disseminating the materials and those who are receiving them, identify the need to address not just language differences, but broader cultural, organizational, and infrastructure differences as well. Examples of the programs that have been developed as well as the challenges and how to address them are discussed in Chaps. 13 and 14. There may now be enough programs within the developing countries to be a resource for new programs. Individuals interested in starting programs in low-resource areas should consider a broad range of partners, including those from the established programs in the U.S. and Europe, as well as those from within their region.

Competencies and Curricula for Informatics Education in Healthcare

Almost half of the chapters in this book address the content of the ideal curriculum for informatics education. Although there is overlap in the proposed competencies and accompanying course materials none of the chapters proposes an identical curriculum, or even identical broad competencies. In most cases this is because the roles for which the individuals are being prepared are different. For instance, in the curricular content described in Chaps. 6 and 10, for healthcare IT administrators and healthcare administrators, there are several courses (in the masters' program) or topics (in the health administration curriculum) related to management, finance, strategic planning and organizational behavior. Both curricula emphasize topics that are a key focus for leaders and managers in an operational environment.

These topics, perhaps with the exception of addressing the HIPAA regulations [2], are absent from both the NLM training programs and the AMIA 10×10 programs that were derived from them, such as the OHSU program described in Chap. 8. That is because the NLM training programs were clearly designed to produce informatics researchers and developers, not managers.

Conversely, while the more applied programs have more management content, some of the foundational informatics topics are usually not included in the applied curricula. Such topics as information retrieval, imaging informatics, in-depth computer science, ontologies, and in-depth coverage of standards that are included in the research and development-focused programs are usually not addressed in detail in the more applied programs. The programs for clinical users of systems such as those for nurses described in Chap. 5 and physicians described in Chap. 9 have still another set of competencies.

The content of the clinical informatics subspecialty examination described in Chap. 4 has similarities to those for all three types of users and is essentially a combination of competencies in basic informatics, IT management, and clinical information management. Because the clinical informatics subspecialty examination currently comprises these three domains, as is noted in Chap. 4, many of the informatics textbooks, which are mainly geared for one or another of these audiences, do not adequately cover the full range of competencies.

This challenge, of integrating different disciplines, has been both an ongoing challenge and an accomplishment for the field of informatics. Despite the difference in the curricula for different roles there are, as noted in Chap. 5, key competencies that are needed, not just for nursing informaticians as discussed in Chap. 5, but for all informaticians. These competencies include computer literacy, information literacy and information management. As described in Chap. 12 and also addressed in Chap. 9, program developers need to identify the intended role of the users, whether their needs are for more foundational or applied learning, the breadth and depth of curricular content needed and the appropriate level of detail. Depending on the intent of the curriculum, computer literacy can mean anything from a very basic comfort with, and understanding of, computers and information technology, to being proficient in developing decision support and other clinical, bioinformatics or clinical and translational research informatics programs. Healthcare administration students may be at one end of the continuum and students in NLM training programs at the other end.

Information literacy in the healthcare setting can include understanding the sources of information, basic vocabularies and terminologies to a detailed understanding of the specific standards needed for communication across systems. Finally, information management, particularly management of electronic information and the development of systems to support the management of the information, is at the heart of informatics in healthcare settings.

Using the key competencies as a basic framework, developers of new programs need to carefully consider what role their students will assume upon graduation and develop the curricula accordingly. While this may be only a small challenge for faculty, it is often difficult for students to navigate the different programs, since students are not always aware of the possible roles and in many cases, students from some of the basic research and development programs wind up in applied roles anyway. To avoid a mismatch of student and faculty expectations, program developers should identify their focus as clearly as possible and recruit students whose interests and skills match the curricular focus.

In some cases, curricular decisions might be made by a consensus process similar to the one that was used to develop the criteria for the clinical informatics certification exam and training program requirements as described in Chap. 4. Even better might be to include a data driven analysis of the competencies of those who are currently fulfilling the roles for whom the program is geared. This is what was done to develop the initial curriculum described in Chap. 6. Such analysis of current workforce roles and functions is recognized as a best practice for developing competencies and competency examinations [3]. The difficulty occurs, however, when existing roles are in transition. For instance, the competency examination program that was part of the ONC workforce program described in Chap. 7, found it challenging to identify competencies by asking individuals currently in somewhat relevant positions about their job responsibilities because the ONC roles were ones that were anticipated to be needed in the future and may not have been part of current job descriptions.

Some combination of expert opinion supplemented if possible by a task analysis of the requirements for the roles the individual will assume is generally considered a good feasible approach to competency development [3].

Chapter 9 includes references to detailed competencies for several informatics roles—those for basic researchers, applied managers, as well as clinician users. Chapter 12 provides examples of competencies in the domain of clinical research informatics. While early informatics education programs often had an implicit understanding of the competencies they were aiming for, as program accreditation efforts become more established, the likelihood is that more explicit competency definitions will be required.

Once the roles and competencies are determined, curricular content to address the competencies needs to be identified. Often new programs do not have the full complement of faculty who can teach the complete range of topics that will be needed. This may be especially acute in programs where a single course is needed in a curriculum which does not otherwise address informatics. An approach discussed in Chaps. 5 and 9 is to have clinical faculty, for instance, take informatics continuing education programs, such as the AMIA 10 × 10 programs (Chap. 8) or a certificate program in informatics. One approach that can work for individual courses or sometimes entire programs, as discussed in Chaps. 13 and 14, is for newly starting programs to partner with existing programs and utilize courses, materials or faculty from these programs. Still another approach is to enlist faculty from other relevant departments for some of the courses. For instance, basic computer science might be able to be taught by computer science faculty rather than only relying on the faculty in the informatics program.

More recently there have been two major efforts to make curricular materials broadly available. As described in Chap. 7, the materials originally developed for the ONC Workforce Program are freely available for educators and have been used by educators worldwide. Similarly, the HIMSTA modules described in Chap. 10 are available for educators in healthcare management educational programs who need to address the required information management competencies. These resources, developed by expert informatics educators, are a tremendous boon even to experienced informatics instructors, but are especially useful for new programs that might not be fully staffed. The other advantage of these materials, in addition to being free to educators, is that they can be used “as is” with narrated lectures available for online education. They also can be modified to fit the needs of particular courses. The disadvantage is that the generic materials may not always meet the needs of the particular program, so educators should be prepared to adapt them.

Online Instructional Strategies

The informatics programs described in this book have deployed a variety of instructional strategies. Most of the NLM training programs described in Chap. 3 are focused on doctoral or post-doctoral students (physicians coming for additional training in informatics). Because of the needs for supervised research of small cohorts of students, often in operational healthcare settings, most of these programs have remained as traditional face-to-face educational programs. On the other hand, as mentioned earlier, in part because of the infrastructure issues, many of the programs in low-resource settings began, and have remained, as primarily online programs (Chap. 14) as have the 10×10 programs (Chap. 8). The ONC workforce programs at the community colleges described in Chap. 7 were a mixture of online, face-to-face, and hybrid programs, with significant online components. Finally, other programs began as face-to-face programs, but eventually transitioned to online programs, as did the program described in Chap. 6.

There are many motivations for decisions to use, or intentionally not use, online instructional strategies. In the countries described in Chap. 14, the motivation was dictated by the unique circumstances of the region—few programs, many potential students spread over wide distances, and a telemedicine infrastructure already established. For other programs such as the one described in Chap. 6, expanding the applicant pool was a major motivator. These reasons are similar to the rationales for MOOCs (Massive open online courses)—the online format permits broad access relatively inexpensively—and may be particularly appropriate for relatively short term programs like the AMIA 10×10 courses, where it would not be feasible for the students who take those courses to be on-site.

In considering online instruction, it is important also to consider the pedagogical, as well as the access, rationale. In looking at the informatics competencies one should ask, "In which mode can students best acquire the necessary knowledge and skills?" In Chap. 4 the authors reiterate that point when they state that some of the competencies that clinical informaticians must have cannot be taught online. On the other hand, educators unfamiliar with online instruction may incorrectly assume that online instruction is valuable only for didactic instruction. As demonstrated in Chap. 11, demonstrations can be effectively conducted online, as can discussions among students. And with modern videoconferencing technologies, synchronous class sessions among dispersed students may not be very different from face-to-face lectures. In fact, studies have shown that interaction among students may be even better in situations where they can communicate online than it is in face-to-face classrooms [4].

Sometimes avoidance of online teaching on the grounds that face-to-face instruction is "better" may just mean that the instructor is more comfortable in a face-to-face situation. Instructor comfort with an online, often asynchronous, mode of teaching is important to consider. As Chap. 2 illustrates, strategies that work in a face-to-face setting may have to be rethought when teaching online. If the instructor is uncomfortable with the medium, the students are likely to be dissatisfied as well.

Hybrid or blended learning environments may offer a way around the limitations of online instruction. In deciding to move the UAB masters' program online (Chap. 6), several face-to-face sessions were deliberately retained. These sessions permit site visits, proctored examinations, and offer the students and instructors an opportunity for more informal interaction. This type of interaction is missing in online instruction, as Chap. 2 discussed. The AMIA 10×10 program discussed in Chap. 8 has most sessions online in an asynchronous mode, but it also includes an in-person session at the AMIA Fall Symposium.

It is likely that the number of informatics programs that are delivered online will continue to grow. The suggestions in Chaps. 2 and 5 include strategies to help instructors become comfortable in this mode of teaching and methods to reduce what has been called "transactional distance [5]," so that both students and faculty can make optimal use of the online resources.

Program Evaluation and Accreditation

As informatics education programs in the various disciplines mature there has been more consensus on the curricula that are needed and a clearer idea of the standards to be used for both internal evaluation and external accreditation. Several disciplines already have accrediting bodies in place that specify the evaluation criteria for informatics education. The informatics education programs may be subspecialty programs or may be incorporated as part of the overall requirements for education in the discipline. For instance, as described in Chap. 5, the American Nurses Association has defined the scope and practice for nursing informatics [6] and nurses are certified by the American Nurses Credentialing Center [7]. Similarly, the Commission on Accreditation of Healthcare Management Education [8] has had a long history of accrediting healthcare management programs, although the criteria related specifically to informatics and information systems have changed over the years (Chap. 10). With the new development of the subspecialty in clinical informatics, as mentioned in Chap. 4, there will need to be training programs in clinical informatics, but the accreditation of those programs will be done by the accrediting body for other medical subspecialties, the Accreditation Council for Graduate Medical Education (ACGME) [9].

Although the funders of the informatics training programs, such as the NLM, are not accrediting bodies per se, they do serve as an external evaluation body. When an existing program applies for renewal funding, the grant reviewers evaluate the structure of the program, its previous accomplishments, and its plans for the future. As described in Chap. 3, NLM has developed criteria for evaluating their overall informatics training program funding initiative, as well as individual program proposals and program accomplishments.

Currently, with the exception of the nursing informatics programs, very few of the informatics training and education programs have undergone formal accreditation. As of 2013, in the U.S. the Commission on Accreditation of Health Informatics and Information Management Education [10] has accredited three masters' level health informatics programs. As of 2013, the International Medical Informatics Association (IMIA) has pilot-tested their accreditation process with universities in Finland, Chile, and Germany (one institution in each country) [11].

At this stage of the development of the field of informatics education, when most programs are not accredited, there are advantages and disadvantages for a program to seek accreditation. One advantage is that accreditation means an outside organization has given a stamp of approval to the quality of the program, which can provide reassurance that the program is following best practices. It can also provide a competitive advantage in attracting students, which was a consideration of IMIA's in developing their accreditation procedures [11]. A potential disadvantage is that any accreditation process introduces more uniformity into curricula across institutions, which may constrain some sites that have been following a very unique curriculum. In addition, it subjects sites to the priorities of the accrediting agency which may not be entirely congruent with an institution's internal priorities. Most of the NLM training programs have already faced that issue when the priorities of the funding agency evolved as was described in Chap. 3.

Once the clinical informatics subspecialty training process gets underway, we can expect to see more accredited training programs, even those that are not focused on producing clinical informaticians. At that time, being accredited is likely to be the standard by which all programs will be judged and those that are not accredited, regardless of how creative and individualized they are, will be at a disadvantage in terms of attracting students and being recognized as high quality by peers. Informatics education program leaders need to stay abreast of developments in the field in regard to accreditation initiatives. They also need to be aware of how they will be judged, and should design, implement and evaluate their programs accordingly.

Conclusion

Many forces are driving the field of informatics education, which is likely to continue evolving over time. The chapters in this book have illustrated the variety of informatics educational programs, strategies, audiences and challenges. This chapter synthesized the lessons learned across the other chapters related to informatics program development strategies, development of competencies and curricula, instruction, and evaluation. As the field of informatics reaches new levels of maturity and greater integration into the healthcare environment, these lessons will be valuable to new and existing informatics educators.

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E.S. Berner (ed.), *Informatics Education in Healthcare*, Health Informatics,
DOI 10.1007/978-1-4471-4078-8, © Springer-Verlag London 2014

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