Information in context: integrating information specialists into practice settings

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An information need (the problem) cannot be divorced from its context. The problem context determines the urgency, granularity of detail, authority, and level of certainty required for an acceptable answer and dictates the expertise and resources that can be brought to bear. The size and diversity of the sources that can be marshaled during clinical problem solving is cognitively unmanageable—too large and too complex for a single person to process effectively in a constrained timeframe. Can the clinical team, as currently constituted, collectively handle this information-processing task, or is there a need for special information expertise on the team? If there is such a need, what is the best way to prepare information specialists to participate in context-based problem solving? This article explores preparation for work in information-rich, problem-solving environments. The authors provide two case studies, one clinical and one bioscientific, that elucidate knowledge and training requirements for information specialists who work as peers in patient care and research settings.

INTRODUCTION

Information needs arise constantly in academic and health care settings, and the process of fulfilling them is often complex. The sources of information that may pertain to any question are diverse in both form and content. The information need itself may be unexpressed or imperfectly understood. The same person does not use the same approach each time to extract, synthesize, and apply knowledge to solve a problem [1]. Clinical medicine is a fertile source of scenarios that illustrate the complexity of the problem, though many of the same problems arise in laboratory and computational research. For example, in treating pa-

Table 1
Health care in 2010, from the *better_healthhere.now* delphi study

	Desirability*
Sources of information	
All current biomedical and clinical journals are available in digital format.	6.6
Clinical information systems integrate patient care data with medical literature.	6.3
More than 50% of patients' history and physical exams in physicians' offices are documented in an electronic medical record.	6.3
There are pooled clinical data in large Internet-based databases, which can be ''mined'' for answers to clinical research questions.	6.1
Clinical information systems integrate patient care data with research data.	5.8
Handheld and desktop technology provide all of the information required for the immediate and continuing care of patients.	5.6
Research reports are structured as databases, enabling new research that extracts data from existing publications.	5.5
Information services	
Internet services deliver to clinicians new research information of exact relevance to their practice.	6.1
Interactive laboratories, learning modules, and clinical simulations are used for continuing medical education (CME) and certification.	6.0
Online modules for personal continuing education and certification are triggered by physicians' learning or practice outcomes.	5.6
Ninety percent of information services are delivered through clinical information systems or customized Web portals.	5.6
Academic medical centers give their patients Internet access to treatment outcomes data for other patients like themselves.	5.1
Quality and outcomes report cards are routinely available on the Internet for hospitals and individual care providers.	5.0
Information roles and skills	
Practitioners routinely seek information online about current best practices in reliable resources.	6.5
Information-management skills are assessed as essential components of clinical skills.	6.1
Librarians and information technology (IT) consultants are available for personal consultation, twenty-four hours-a-day via real-time, interactive videoconferencing.	5.5
Online consulting services help patients interpret test results and treatment plans.	5.2
''Infomediaries''—who synthesize medical literature, clinical data, and research— emerge as members of the health care team.	4.8
Patients routinely access results of laboratory and other diagnostic tests over the Internet, without needing to go through their physicians' offices.	4.3

* 1 = least desirable; 7 = most desirable.

tients, clinicians may need to construct answers by drawing information from many sources, including: personal knowledge, curbside consultations with colleagues, test results, printed and digital medical records, conversations with patients, biomedical image scans, visual inspection of biological specimens, statistical summaries of disease data, and evidence found in current articles or books. Having overcome the challenges of acquiring the relevant pieces of information, clinicians must now weigh them against one another and fit what they select into coherent frameworks that can guide their actions [2]. A similar problem-solving scenario could easily be sketched for cell biologists, computational chemists, nursing school deans, or anatomy instructors. The point is that an information need (the problem) cannot be divorced from its context. The problem's context determines the urgency, granularity of detail, authority, and level of certainty required for an acceptable answer and dictates the expertise and resources that can be brought to bear at a particular point in time.

The context of biomedical and health problem solving today is fundamentally different from any time in the past. Published information, once consulted only in the library, is now routinely used in the office, at the bench or bedside, or in patients' homes. Increasingly, both patients and clinicians perform online literature searches on their own, as questions arise. In some settings, an integrated view of relevant information sources, knowledge based and clinical, is available at the point of need (i.e., in context) [3, 4]. The size and diversity of the clinical problem space is cognitively unmanageable—too many sources, too much overlap, and too complex for a single person to process effectively in a constrained timeframe [5]. Yet, indications suggest that in the coming decade, the biomedical and clinical information environments will become considerably richer and more complex. For example, respondents to the Association of American Medical College's 1999 *better_health@here.now* delphi study provided a thought-provoking vision of future information sources, services, and skills (Table 1) [6].

Many people seek to make it easier to cope with the information overload problem. Two common approaches in the clinical domains are:

- change the search process, by providing a search engine that searches across many different kinds of publications at the same time [7] or by delivering published knowledge from ''inside'' the clinical information system [8]
- change the information, by making it easier to find

pertinent data quickly [9] or by synthesizing research findings in advance [10]

If health professionals are becoming more sophisticated users of information systems, could the clinical team, as currently constituted, collectively handle this information-processing task? Davidoff and Florance suggest that an information specialist, the informationist, could be added to the team, someone whose expertise differs from that of other team members [11]. As Plutchak notes, the informationist is not a new idea so much as refinement of an idea that has sprouted but not flourished [12]. There are clinical settings today in which nurses, pharmacists, or librarians provide specialized information services to a clinical team [13]. There are basic science research settings that include library-employed scientist-consultants [14]. However, the integration of information professionals into the workplace of their clients and colleagues and the training of information specialists to work in a context *outside* the library setting is probably no more common today than in 1982, when Matheson and Cooper, speaking of staffing requirements for ''stage 3'' (i.e., advanced) libraries, said: ''Needed are professionals who, by virtue of experience or cross-training in medicine, basic sciences, computer science, information science, and library science, can work across professional boundaries'' [15].

There are two central questions, then. First, what is the best way to prepare people to work in information-rich environments? Second, what is the best way to incorporate information expertise into the context of problem solving? The remainder of this article focuses on the education and training of information specialists to function as peers in patient care and biomedical research settings.

PRACTICUM TRAINING FOR HEALTH SCIENCES INFORMATION MANAGEMENT

The health professions have long used a two-pronged approach in educational programs, combining didactic courses with apprenticeship experience. Thus, during their formal education, medical students, nurses, and graduate students work in hospitals and clinics and labs like those they will join after graduation. Whether integrated with the disciplinary coursework or undertaken separately, practicum training in the health professions complements, and is as important as, the courses that provide the domain-specific intellectual foundations. This curriculum model is not common to schools of library and information science.

Librarians, whose *raison d'etre* is to fulfill the information needs of caregivers or researchers, must now expect to meet those needs in practice settings or laboratories rather than libraries, but most library school programs leave immersion in specialty or disciplinary knowledge (i.e., the context) of future work to occur after graduation. Professional training in library schools emphasizes the design, organization, and management of information resources and systems [16]. Someone who wants to work in a health sciences library can graduate from most library schools today without ever taking a course in anatomy or epidemiology of disease or biochemistry. Library school students may learn *about* laboratory research or health services administration during their professional education, but they are rarely asked to complement that learning with work *in* research labs or health clinics. If student librarians do receive practicum training, it usually takes place in libraries [17, 18]. Even when their practicum training includes work in health sciences libraries, students may not experience immersion in the work settings of those they assist.

Nearly a decade ago, noting significant changes in the health information environment, the Medical Library Association issued *Platform for Change,* its educational policy statement [19]. Regarding the need for specialized knowledge and skill, the report noted ''Health sciences librarians must understand the contexts in which the need for biomedical and related information emerges and the unique ways of perceiving and interpreting those environments.'' *Platform for Change* stopped short of calling for practicum training or ''immersion experiences'' for health sciences librarians. Rather, it proposed an inventory of knowledge and skills whose health sciences information services component reflects a need for context-relevant services. Pertinent elements included: understanding information needs of health practitioners, researchers, and educators; analyzing, evaluating, and synthesizing information for identified needs; and developing services tailored to meet needs of individual and group users.

In 1995, the National Library of Medicine (NLM) awarded seven planning grants aimed at addressing recommendations of its Planning Panel on the Education and Training of Health Sciences Librarians [20]. Several reports from the grantees alluded to the need for practicums, internships, and residencies. One mentioned the option of placement in a health care team [21], and one described a plan for practical training of librarians in health care settings [22]. In response to the report and experiences of the planners, NLM offered individualized practicum experiences through its applied informatics fellowships [23] and made special funds available to its Medical Informatics Research Training Centers for programs targeted to librarians* [24].

* Links to program descriptions for each of the Medical Informatics Research Training Centers may be viewed at http://www.nlm.nih.gov/ep/curr_inst_grantees.html.

In its latest Long Range Plan, NLM explicitly recognizes the need for context-based information specialists [25]. Objective 3.2, Further Training in Medical Informatics and Librarianship, includes these program plan elements: (1) to explore training health sciences librarians at institutions that have integrated the library into clinical, research, and/or educational activities and (2) to explore the notion of specialist librarians in three areas: (a) clinical informatics—working directly in the clinical intensive care setting, providing just-in-time, patient-specific information; (b) health policy—providing advanced assistance to health policy makers and public health professionals with information needs that span many disciplines; and (c) bioinformatics—assisting researchers in sophisticated use of molecular biology and genetic databases.

DOMAIN CROSS-TRAINING FOR HEALTH SCIENCES INFORMATION MANAGEMENT

In 1993, reviewing their experiences, in developing and managing the Genome Data Base, Florance and Matheson noted that domain knowledge in scientific disciplines was required of library staff who worked with database content and scientific editors [26]. In 1994, NLM convened a planning panel to analyze possible training programs for health sciences librarianship. In its report, the panel noted, ''it may not be enough for [health sciences librarians] to confine their preparation to library/information science courses'' [27]. One NLM-funded planning study asked a panel of sixty employers of health sciences librarians about desirable program content for a master's-level health specialization. Slightly more than one-third of the respondents mentioned general knowledge of biomedical and health sciences; about one-sixth mentioned field experience in a health care or research setting [28].

Library schools with health sciences specializations often require that elective courses be taken from other schools, such as nursing or public health. However, the suggested elective courses are usually focused on information management or program administration, not on the specialty or discipline itself [29]. Health professions students today must learn basic skills of finding and managing information effectively. Incorporating information management concepts and skills into formal curricula of health professions programs has proceeded unevenly, but most schools now require at least basic literature search and retrieval competency, and some have expanded their graduation requirements to include an array of increasingly sophisticated information skills.† However, formal training in foundations of information sciences or medical informatics is not yet a common feature of health professions programs and is rare in graduate programs for basic biological sciences. Thus, despite the oft-stated view that medicine is an information profession and despite the fact that basic research in genomics and proteomics requires the use of sophisticated computer programs, the members of a clinical or laboratory team of today have various levels of information fluency [30] but no common foundation in information retrieval and management.

If the building blocks of education and training for context-based information specialists are knowledge of a subject discipline and practicum experience in that field, and these are not addressed in the initial professional training, how may they be obtained? The two case studies that follow describe programs that are, in a sense, working prototypes for information specialist training. The first case study describes Vanderbilt University's Clinical Informatics Consult Service, in which librarians acquire clinical domain knowledge. The second describes the University of Washington's Bioinformatics Service, in which bioscientists acquire knowledge of library and information sciences. Each case study offers insights into the knowledge and skills required of information specialists who participate as peers ''in context.''

CASE STUDY #1: CLINICAL INFORMATICS CONSULT SERVICE (CICS) AT VANDERBILT UNIVERSITY MEDICAL CENTER

With the increasing acknowledgment of knowledge management and evidence-based medicine as key influences in the current and future practice of medicine as well as library and information sciences, the need for information services as an integral part of clinical practice grows more pressing. While prior clinical librarianship programs have taken librarians into clinical environments, traditionally the role of information specialists has been that of added bystanders visiting from another area rather than active and fully integrated members of the clinical team itself. For effective practice, the essential components of a successful partnership of equals between the clinical and library environments are (1) complete integration of the librarian into the clinical team, (2) librarians' strong, continuously growing knowledge of the clinical field as well as information retrieval, and (3) supportive library cultures in which lifelong learning and commitment to context-based services are unwavering [31, 32].

For several years, the Eskind Biomedical Library (EBL) has operated the Clinical Informatics Consult Service (CICS) that integrates librarians into clinical teams to play a proactive role in providing applicable information and training in an intensive patient-care setting. While this program is well described else-

† See, for example, Report II: contemporary issues in medicine: medical informatics and population health. medical school objectives project. Washington, DC: Association of American Medical Colleges, Jun 1998.

where [33], the cornerstones of creating and maintaining the service are summarized below.

CICS information specialists

Crucial to the success of a program that integrates librarians into the clinical setting is a cultural change in the library itself [34–36]. In addition to the practical need to free librarians from library-based patron services, an appreciation for information in context and for lifelong learning is also extremely important. The participation of librarians as members of clinical teams changes not only the participating librarians but the library itself. The knowledge acquired by ''rounding'' librarians (those who make rounds with a clinical team) adds a new value to all aspects of biomedical information service, not merely the CICS. Rounding librarians experience the impact of context in their daily work, providing information on a just-in-time, situation-specific basis and witnessing information needs in their natural expression and setting as well as the impact upon patient care of the information they provide. Clinical librarianship provides a direct link between health sciences librarianship and clinical practice. However, for this link to remain effective, the library environment must be supportive of a continuous learning process for support staff and librarians, as there will be a constant need for acquiring new knowledge and new skills. It is essential that rounding librarians acquire a solid personal understanding of clinical medicine, including basic concepts as well as those specific to their teams (i.e., hematology/oncology, trauma, neonatology, etc.). Continually working to stay up to date is important for both the librarians' understanding and their roles in alerting the team to new findings in their fields. This fundamental aspect of the CICS service requires an environment where lifelong learning will be fostered and where the entire library is organized to gain from the experiences of rounding librarians.

One example of how continuous improvement and learning is supported for the rounding librarians involves opportunities for them to review and improve the searching and literature filtering process. At EBL, monthly conferences called SearchTalk and the Filtering Teaching Conference (FTC) bring librarians together to examine a particular question presented during rounds. They develop a gold standard strategy for searching, filtering, and summarizing based on everyone's efforts to refine individual strategies and finalize a group consensus on the best approach for that query. This process can easily be implemented by one or two librarians in smaller settings. It provides a useful and constructive setting for feedback and assistance from colleagues.

It is imperative that filtering of the literature goes beyond the obvious medical concepts. Hence, rounding librarians must take time to learn and understand some basic principles of study design, incorporating areas such as biostatistics into their knowledge building. Rounding librarians must also overcome personal concerns about presenting information to their clinical teams. Increasing knowledge gained from active participation in the SearchTalk and FTC, coupled with applicable courses and subject area conferences, builds confidence in rounding librarians, and success in interacting with the other members of the clinical team provides an additional measure of reassurance. Time and effort are required to earn the trust of a clinical team, but this investment is key to the success of such a program. It also improves service in the traditional library setting, as it gives clinicians a new view of librarians, increasing confidence in librarians' abilities to meet clinical information needs.

Many people suggest that members of the traditional clinical team, such as nutritionists or pharmacists, could easily meet the information needs addressed by the CICS information specialists. The CICS program strongly fosters clinician independence in searching the literature, particularly to address fundamental questions within individual specialties or unit needs. It is unrealistic to believe that librarians will always be available to answer every question in every setting. In addition, clinicians are likely to already have some level of proficiency in database searching, particularly in their areas of expertise. In many cases, though, the literature addressing a question may be quite complex, requiring the representation of multiple viewpoints [37]. Professional information specialists are better positioned to address such needs, utilizing their knowledge of information resources to quickly identify and assimilate the spectrum of items in each viewpoint, selecting the best example of each before filtering and summarizing the final package. The net effect is saving valuable clinician time. While any clinician could—given sufficient time, relevant training, and appropriate resources—provide the response to such questions, busy teams must allocate resources carefully. The CICS information specialists fill the information needs more efficiently, reserving the time and attention of expert clinicians for direct patient care. This concrete value is one of the truly unique features of CICS: experts in clinical medicine, in information sciences, and in biostatistics are not new, but the integration of that expertise in a single team member, performing the central role of an information expert for a clinical team, remains uncommon.

Lessons learned from CICS operations

In expanding its service beyond the critical care units in which it began, the EBL's CICS has found that most clinical teams have certain information needs that frequently repeat. Eventually, these needs can be addressed by the clinicians themselves with search assistance and training from the CICS librarian as needed. Consequently, the service has evolved. The rounding librarians now deal primarily with complex clinical queries and offer training and search strategy aid for basic repetitive questions, such as requests for overviews of particular diseases or treatment options [38]. In addition, some clinical units work with CICS on a consultation basis, with the librarians rounding for initial periods on normal schedules, then transitioning to single monthly sessions with the team, serving as on-call consultants the remainder of the time. In this approach, clinicians from the team request a CICS consultation much as they request a surgical consultation or a cardiac consultation from colleagues in another specialty. By diversifying its approach, CICS can continue to grow and collaborate with additional units without the requirement of enormous staffing demands. However, to make these alternatives possible, the rounding librarians must first develop strong trust relationships with the clinical teams, forging partnerships that foster mutual communication and confidence in the clinical environment for optimum patient care informed by the finest information available.

In addition to the above-noted benefits of integrating librarians into the clinical environment, there are benefits of the CICS that extend into the library itself. At the individual level, the increased understanding and awareness of clinical issues and demands plays a role in every aspect of the rounding librarians' endeavors, not only the rounding itself. Clinical librarians, who receive a search request through traditional reference routes such as telephone or service desk time, bring a distinctly different perspective to reference interviews because of their clinical expertise. These librarians frequently think of questions to help refine and enhance results that would not have come to mind before their experiences working directly with patient care teams in their own environments. This yields not only improved service as information professionals, but increased satisfaction from patrons, adding considerable value to the library's services. There is also the transfer of the rounding librarians' skills and knowledge to the rest of the library staff through formal means like the FTC and informal means such as role modeling. CICS also provides the opportunity to study information needs in their natural and spontaneous occurrence (i.e., in context), something librarians rarely have the opportunity to do with traditional reference routes, which have patrons calling or stopping by to articulate specific requests. The opportunity to better understand needs in context enhances librarians' role as key players in today's clinical environment.

As the case study suggests, EBL's Clinical Informatics service is a fluid program that is constantly being evaluated and adapted to work best in each setting. What works in one unit of a medical center may not serve the needs of another area. Likewise, the precise approach adapted to one institution may not fit in another setting. Additionally, one or two trained professionals cannot simply be employed with the assumption that a successful CICS service will simply materialize. Implementation is not merely a matter of assembling pieces from that point forward; several foundations are required for such a program to succeed, including management commitment, peer feedback, and continuous updating of skills and knowledge.

CASE STUDY # 2: TEAMWORK IN DELIVERY OF NEW BIOINFORMATICS SERVICES AT THE UNIVERSITY OF WASHINGTON

Teamwork among health professionals is one of the critical elements to providing quality patient care. Teamwork implies not only an appropriate division of labor, but also a coordinated and integrated approach. At the University of Washington (UW), the library itself is a team member, a core member of the interprofessional education collaboration, and librarians are members of instructional teams, clinical care rounds, and information systems development teams. Librarians coordinate license agreements for shared digital references and operate the computing commons. Such team and shared service roles require diverse abilities that may not be considered traditional library skills. For example, librarians providing clinical answers must know evidence-based decision techniques including statistics use and summarization as well as formulation, sources, and literature-filtering strategies. Librarians who participate in teams must also have domain-specific knowledge. The key thread in these collaborations, whether inside or outside the library, is creating common ground, shared services, and multifaceted teams.

Although there have been examples of librarians working with clinical teams, few libraries have sought to infuse this collaborative model into the biosciences domain [39–41]. Addressing the information needs of basic scientists developed into a new bioinformatics service at UW in 1994. Funded in part by a contribution from the Howard Hughes Medical Institute, the initial service had these goals: (1) providing needs analysis; (2) offering a molecular biology consultation service; (3) training in the skills for discovery, search, and manipulation of gene and protein data; (4) building a molecular biologist toolkit [42]; and (5) communicating regularly about new resources and services.

The bioinformationist

Prerequisites for an information specialist to lead the Bioinformatics Service were: (1) experience in biore-

Figure 1
Context-based approach of University of Washington's bioinformatics consulting service

Solving research questions using gene and protein sequence tools

In pursuit of information about genes important to breast cancer, Karen Swisshelm, Ph.D., associate professor of pathology, discovered a useful source and guide to molecular sequence analysis tools. Swisshelm's lab had cloned a cDNA fragment using differential display PCR that was expressed at elevated levels in senescent human mammary epithelial cells. They sequenced the DNA, and then performed some initial BLAST sequence database searching to discover what was known about the gene.

At this point, she contacted Stuart Yarfitz, Ph.D., the library's bioinformatics consultant, for assistance in interpreting these results. Yarfitz helped determine that the DNA fragment was novel and not closely related to other known gene sequences. The researchers went back to the lab and spent several months performing further cloning and DNA sequencing. Yarfitz assisted them with additional database searches and protein functional analyses that revealed a significant homology to epithelial cell membrane protein genes. Swisshelm named the protein SEMP1, for senescence-associated epithelial membrane protein, and determined that it was part of a protein superfamily that includes claudin-1, a tight junction associated protein. She is now pursuing functional studies of SEMP1 to determine its precise subcellular localization and to test the hypothesis that it may act as a tumor suppressor gene.

Swisshelm says of the library's bioinformatics services program that her lab ''could not function efficiently without these valuable resources. Currently we use the HSL-sponsored Vector NTI as both a bioinformatics interface and as our 'lab log' of constructs'' [43].

search; (2) ability to use quantitative data to analyze needs; (3) instructional and Web development skills; (4) experience with specialized tools in molecular biology, basic sciences literature, and general bioscience databases; and (5) ability to filter and organize resources to optimize research workflow. Because the position description was a crossover of librarian and researcher, the best candidates seemed likely to be either ones with a doctor of philosophy (Ph.D.) ready to refocus on information problems or librarians with a bachelor's or master's of science (BS or MS) in a bioscience discipline and relevant research experience. To allow for either case, the position was rated as a professional appointment, rather than as a librarian. A researcher in molecular and cellular biology with a strong interest in provision of information service was selected to lead UW's fledgling program.

Initially, the primary clients for the Bioinformatics Service were faculty in eleven UW laboratories funded by the Howard Hughes Medical Institute. The service quickly expanded to include molecular and cellular biology researchers in the School of Medicine's basic sciences departments, and ultimately developed a significant user base among clinical researchers as well. During this period, the key components of the bioinformatics service evolved to include a heavily subscribed series of bioinformatics classes covering such topics as BLAST sequence searching, sequence analysis using Vector NTI, and support for networked sequence software at desktops in labs. The scenario in Figure 1 illustrates the context-based approach of UW's bioinformatics consulting service and illustrates the ''team'' approach to problem solving.

Now in its seventh year, the Bioinformatics Service is entering a second phase. Like other research-intense institutions, UW is developing a core-services approach to support microarray data, gene and protein sequencing, and other large-scale data-driven research. The first component is a BioCommons Computing Center, a collaboration of the School of Medicine, the library, and the School of Public Health. Key aims of this shared service are: (1) site licenses and discount agreements, (2) shared repository of advanced tools developed in UW labs, (3) gene and protein sequencing consultation, and (4) training in selection and use of the best available sequencing and analysis software tools. SeqHelp, developed at UW, and Genemax, a commercial product, are the first of the new tools available to researchers through the BioCommons.

In phase two, the library moves into a collaborative role with the two schools to develop a large-scale service with a seamless suite of services. The bioinformationist works in a team with a programmer and a systems administrator to provide more specialized and technologically advanced support. The bioinformationist takes on new project-management and team-leader roles, coordinating across departments while continuing to provide high-level consultation for specific questions. Affiliated with the library, the bioinformationist is firmly planted in the research labs and the BioCommons. The ''library'' side of the bioinformationist's expertise continues to focus on building the integrated molecular biologist toolkit and teaching people to use it effectively. The educational program employs a multifaceted set of instructional methods and addresses the needs of both graduate student and faculty researchers.

Lessons learned from the Bioinformatics Service

Crossing the cultural boundaries between the research and service paradigms provided lessons about the knowledge and skills necessary for a successful bioinformation specialist program. For example, certain skills are needed regardless of the specialists' research or library training. Key skills and training issues include:

- strong research background focused on molecular biology
- understanding of both the research and service cultures
- awareness of current research developments
- knowledge of applied bioinformatics from a broad research perspective
- ability to teach a diverse group of learners
- skill with both bibliographic and specialized biologic resources

■ familiarity with programming, algorithms, statistics, and data management

The success of the bioinformatics program resulted in part from initial cross-training in information and library sciences. The bioinformatics specialist's involvement in selecting, organizing, and communicating traditional and nontraditional content for the toolkit enriched his understanding and perspective of the need for a ''user-centered'' approach. There was immediate benefit for the library—for example, informed insight into the needs of researchers fast-tracked the library's transition to electronic journals and integrated linkage from the PubMed MEDLINE system. Further, the bioinformatics specialist's active participation in general information service and the library's proactive liaison program to departments broadened and deepened the dialog with basic sciences faculty who did not use the library.

The information specialist working in context-based collaborations with research scientists requires preparation in library services, informatics, and specific domains. Basic sciences knowledge may be centered in genomics, neuroinformatics, or clinical research. Information science knowledge should include data mining, data organization, and knowledge representation. The best information tool will allow researchers to ask and answer their questions seamlessly, in context. Drawing together a diversity of disciplines is the key to creating this tool.

Traditional library or information science programs do not provide (1) the subject competency or (2) the acculturation experience necessary for success in a program such as the one developed at UW. It is anticipated that librarians stepping into bioinformationist roles must hold a minimum of an MS, with backgrounds in biochemistry; research experience, including protocol design and literature review; statistics; and computational skills. An immersion experience or apprenticeship in a lab is needed to break the ''cultural barrier'' of science. On the information sciences side of the equation, requirements for bioresearchers stepping into this role include immersion or apprenticeship in information needs assessment, instructional design and techniques, advanced use of bibliographic databases and other digital resources, and understanding of the role of customer service in an interdisciplinary environment. One approach to achieving the ideal mix is a master's program jointly offered between library schools and biology or other basic science departments, with internships in libraries committed to collaborative shared service like the BioCommons [44].

DISCUSSION AND CONCLUSION

As the case studies suggest, preparing information specialists to work in information-rich environments and to participate as peers in problem solving requires adjustments in training and work activities as well as long-term management commitment. Some important training considerations include:

■ Information specialists who want to work as peers in clinical or research teams need basic knowledge about two fields—information and library sciences and discipline knowledge of scientific or clinical domains. That is, informationists must be cross-trained. Neither professional education programs for information professionals nor those for health professionals currently provide a curriculum base to support this cross-training.

■ The candidates for context-based information services may come from either ''side''—that is, from the sciences and clinical specialties or from library and information sciences. In both cases, the additional knowledgebase must be gained through formal coursework and internship. Courses in the biomedical sciences may be relatively accessible to practicing health sciences librarians located at academic health sciences centers, but the reverse is not the case for graduate students, researchers, and clinicians who wish to receive cross-training in the information sciences.

■ Professional training for information specialists should include an internship in a practice setting common to the domain knowledge being acquired. The practicum experience, whether in a lab or clinical setting, does several things. Besides introducing specialists to the kinds of questions and information needs that arise in a given context, it ''acculturates'' them to the norms and standards of the other domain specialists on the team. Acquiring cultural competence is as important as learning practical skills.

Management considerations include the following:

■ Informationists, whether in research or clinical settings, add value in two ways. They bring unique information skills to the domain setting and bring domain knowledge back to the library. Informationists add value to the context setting that can be measured in terms of salary expenditures trade-offs, outcomes, and user satisfaction. Likewise, the value to libraries can be measured in a similar way. Reporting values and outcomes should be a fundamental component of ongoing evaluation for context-based services.

■ Cross-trained information specialists face a special challenge, in that they must keep abreast of advances in two domains. A library with information specialists must change its own culture to accommodate this continuous learning and feedback loop. The home library may also need to institute new internal communication mechanisms to formalize the flow of new insights among library staff. There is also a need for communication with information specialists doing similar work at other institutions.

■ Davidoff and Florance surmised that an additional benefit of informationist services might be ''complete systematic feedback on what kinds of clinical questions are asked most often, and which questions lack satisfactory answers. Such 'meta-information' could contribute importantly to the definition of clinical research agendas'' [45]. It is also possible that cross-trained information specialists, who work with more than one clinical group or provide services to more than one lab, will aid in the discovery of cross-disciplinary linkages, acting as a kind of human incarnation of Swanson and Smalheiser's approach for linking complementary literatures [46].

Academic health sciences centers (AHSCs) are uniquely qualified to take a leadership role in the training of information professionals for context-based work in health-related settings. First, each has a health sciences library that can implement the program, and some have academic informatics programs that may already offer formal coursework in information sciences. Second, the health professions and graduate training programs in AHSCs are natural sources of candidates for cross-training. Third, the notion of internships is well established and accepted in these settings. Fourth, mechanisms are present that support development of a certification program, if that proves to be desirable.

It is easy to imagine a future in which the professional staff of the health sciences library function as the faculty for such a program:

- acting as preceptors for trainees and arranging for domain preceptors
- drawing upon internal and external resources to design trainee-appropriate curricula in information sciences and management
- brokering arrangements for librarians to take courses in health professions schools
- mentoring and evaluating the specialist-trainees
- arranging practicum experiences
- documenting the costs and benefits of context-based information services

Efforts to change the curricula of library schools and health professions programs have met with limited success to date. Rather than trying to change existing professional education programs, perhaps it is time to try a new approach. Why not implement a post-graduate training program, located in AHSCs, that prepares information specialists to work as peers in problem-solving contexts? Locating the program in the AHSC makes it possible to leverage the expertise and management structure that exists in health sciences libraries, making libraries both incubators and homes to a new breed of information specialists.

In addition to preparing new specialists, a training program of this kind can establish a foundation for answering the second central question of this paper—what is the best way to incorporate information expertise into the context of problem solving? The notion of context-based information specialists combines the two most common strategies for coping with information overload by changing the search process and changing the information. The best way to test this idea is to try it and to systematically evaluate its effects across a number of institutions and settings.

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