Tufts Health Sciences Database: Lessons, Issues, and Opportunities

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ABSTRACT

The authors present their seven-year experience with developing the Tufts Health Sciences Database (Tufts HSDB), a database-driven information management system that combines the strengths of a digital library, content delivery tools, and curriculum management. They describe a future where online tools will provide a health sciences learning infrastructure that fosters the work of an increasingly interdisciplinary community of learners and allows content to be shared across institutions as well as with academic and commercial information repositories.

The authors note the key partners in Tufts HSDB's success—the close collaboration of the health sciences library, educational affairs, and information technology staff. Tufts HSDB moved quickly from serving the medical curriculum to supporting Tufts' veterinary, dental, biomedical sciences, and nutrition schools, thus leveraging Tufts HSDB research and development with university-wide efforts including Internet2 middleware, wireless access, information security, and digital libraries. The authors identify major effects on teaching and learning, e.g., what is better taught with multimedia, how faculty preparation and student learning time can be more efficient and effective, how content integration for interdisciplinary teaching and learning is promoted, and how continuous improvement methods can be integrated. Also addressed are issues of faculty development, copyright and intellectual property, budgetary concerns, and coordinating IT across schools and hospitals. The authors describe Tufts' recent experience with sharing its infrastructure with other schools, and welcome inquiries from those wishing to explore national and international partnerships to create a truly open and integrated infrastructure for education across the health sciences.


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intellectual property, budgetary concerns, and coordinating information technology (IT) across schools and hospitals. “Opportunities” recount our experience with migrating the infrastructure to another medical school; highlight future directions for Tufts HSDB; touch upon the evolving roles of health sciences libraries, academic IT, and offices of medical education; and reflect on the opportunities for outside partnerships to create a truly open and integrated infrastructure for education across the health sciences and beyond.

**BACKGROUND**

Tufts HSDB started in 1995 as a modest Tufts Health Sciences Library project to create an image database that would improve student access to study slides by making the images available online. Startup funds from Tufts University School of Medicine and a subsequent grant from the National Library of Medicine allowed the project to quickly expand to include course syllabi, video clips, lecture slides with audio, self-assessment quizzes, etc. Whereas many schools use CD-ROMs or Web-based course materials that on the surface resemble what Tufts HSDB offers, there are crucial differences between the two approaches. Most Web-based course materials are entered into shells that stand alone and must be used “as is.” At Tufts, teaching resources (text, images, sound, etc.) are taken apart and entered as individually labeled pieces of data into a robust, object-oriented, relational database infrastructure. Labeling metadata is based on the OCLC Dublin Core and complies with emerging national standards for the labeling of learning objects (such as IMS Global Learning Consortium and SCORM from the Advanced Distributed Learning Initiative). These labeled pieces can be shared and reused (like interchangeable Legos) by multiple faculty, can be linked with any other piece(s), can be searched against an index based on the UMLS (Unified Medical Language System, the nationally standardized medical thesaurus), and can be easily migrated to the next new technology. We have created a document architecture that facilitates sharing content, and a data repository onto which is built a variety of user and authoring interfaces. Herein lies the power of Tufts HSDB. Teaching resources “living” on Tufts HSDB remain flexible and adaptable as both medicine and technology evolve at a dizzying pace—key benefits in a discipline and technology that both require constant updating.

The Association of American Medical Colleges (AAMC) with the Milbank Foundation selected Tufts as one of ten schools noted for innovative curricular changes largely based on the work of Tufts HSDB. Tufts HSDB has been recognized by the national CIO Magazine Enterprise Value Award for Innovative IT Development. Tufts was the first university program to win in the award’s ten-year history. EDUCAUSE and library organizations have also noted the contributions of Tufts HSDB in education.

Tufts HSDB currently uses a MySQL database and Perl programming language for user and authoring interfaces. The server architecture includes a Sun Enterprise 250 (database repository), and two Sun Ultra 60s, one serving as Web server, the other as media server (Real Server and Zoom Server). An older Sun Sparc 20 serves as a log server. Major features include:

- Portal for students and faculty to access curricular material
- Administrative tools, online schedules, and evaluations
- Search engine, UMLS-indexed, across health sciences schools
- XML document architecture for print or Web
- Authoring interfaces for content creation and revision and upload
- Self-study quizzes linked to curricular material
- Image collections, printable to PDF, virtual microscope
- Repository for student notes
- Personal notes and folders
- Discussion lists

Over the past four years, content from the medical, dental, and veterinary schools has increased sixfold, and user content requests have jumped from 84,000 in 1997 to over 2.5 million this year for about 1,000 students. The Tufts Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy joined the other health sciences schools this past year.

**LESSONS LEARNED**

**Key Partners for Success**

The success of Tufts HSDB can be attributed to the close collaboration of “champions” from key arms of the educational organization: the health sciences library, the office of educational affairs, and information technology. These champions support the core educational mission represented by the familiar triangular relationship among content, the faculty, and students (Figure 1). Tufts has had the advantage of being both large enough to have the proper elements, and small enough to encourage the different groups to communicate and work together to leverage strengths and resources.

The Health Sciences Library (HSL) was a leader in Tufts’ Integrated Advanced Information Management Systems (IAIMS) planning grant in 1990, and in the subsequent National Library of Medicine (NLM) grant in 1997. The HSL thus was the natural partner to house the initial online curricular content, beginning as an outgrowth of established media center reserves. Library staff have longstanding involvement with our problem-based learning program and
partners in the educational process.\textsuperscript{14,15}

directional of contemporary libraries’ becoming more active
a natural evolution of online services, and supports the
curricular content to complement these holdings has been
University libraries and across the New England regional
licensed resources. Sharing resources among our six Tufts
including demand for online support for both internal and
that while foot traffic is clearly down, Internet traffic is up,
curriculum committee, and most recently with our evidence-

curriculum content triangle. Such a partnership is key for other institutions to succeed
with similar initiatives.

Figure 1. Partners in education. Success of the Tufts Health Sciences
Database is due to the collaborative efforts of the health sciences library,
office of educational affairs (OEA), and information technology (IT) to support
the educational mission as represented by the traditional student–faculty–
content triangle. Such a partnership is key for other institutions to succeed
with similar initiatives.

This integrated approach helps to ensure efficient development
and operation of Tufts HSDB infrastructure, provides
for the electronic exchange of vital administrative data, and
facilitates front-line technology support for users of Tufts
HSDB. These university-wide IT partnerships also serve to
leverage Tufts HSDB research and development with uni-
versity-wide efforts such as Internet2 middleware\textsuperscript{16}, wireless
access, information security, and digital libraries.

Faculty champions were quickly identified to become the
early adopters of Tufts HSDB tools. After entering their
content onto the system, and using the tools both in and out
of the classroom, some early naysayers later became Tufts
HSDB’s strongest advocates. Student input through focus
groups, surveys, and informal feedback allowed us to identify
and prioritize educational needs that could be better served
with online tools. In these few short years, we have moved
from needing to train entering students in basic computer
skills to concentrating on higher-level resource training and
keeping pace with demand for new services.

Forces for Change in Medical Education

Tremendous multidirectional forces are pushing us toward
ever-greater use of IT tools in medical education, research,
and practice. Medical content continues to increase in
amount and complexity, with a real need for interdisciplinary
learning and thinking, not only across medical disciplines, but
also across veterinary, dental, public health, and even socio-
political areas. Recent efforts to provide bioterrorism-related
education for health providers illustrate this need for cross-
disciplinary collaboration, as well as rapid creation and
delivery of new content. Yet medical curricula change
notoriously slowly. Can online tools support the development
and delivery of interdisciplinary education that is responsive
to needs in real time? Faculty time constraints in clinical and
research endeavors strain their ability to stay current in their
teaching materials and methods. Can online tools help ease
the strain and make teaching more effective? Students enter
medicine with increasing expectations of online resources,
not only for classroom learning and self-study, but also in the
care of patients at off-campus sites. Is our educational model
fostering the necessary lifelong learning skills while main-
taining student contact with faculty and patients? Examples
throughout the remainder of this section highlight where we
feel online educational tools can address each of these and
related areas.

Database Structure for Growth, Management,
and Integration

In the mid ’90s, we decided to grow our online curriculum
system within a database structure with a Web interface
rather than through independent HTML Web pages. Now,
several years later, the wisdom of that choice is evident as schools choosing the HTML Web page route struggle to manage hundreds or even thousands of individual Web pages. Faculty realize that they cannot easily update their materials, and that users cannot easily search across the independent Web pages. Despite great improvements in the ease of Web page design, maintenance, and searching, there are inherent problems with establishing and managing a curriculum through independent Web pages.

In contrast, Tufts HSDB’s robust database structure has facilitated relatively painless management and annual upgrades needed to keep pace with changing technologies. Our database structure can treat individually each piece of content (image, text, video clip, audio, etc.) to be labeled, searched, linked, or modified. The benefits of this approach are enormous, including providing tremendous flexibility in the use of each content item across courses and schools. For instance, an image of anthrax spores could be embedded in an online syllabus in infectious disease in medicine, in a PowerPoint presentation for a lecture in the veterinary curriculum, or in a self-study module with added instructional overlays for a public health program. One image, stored once, can be used multiple ways and easily migrated to the next-generation technology.

Lessons from the Laboratory

How did we begin? The OEA brainstormed with the Tufts HSDB project team and asked, “Where would online course materials represent a clear improvement in current didactic practice and showcase a strength of a database-driven system?” The answer was easy. Histology was becoming difficult to teach with annual deterioration of original slide sets (replacement costs estimated at $200,000), the difficulty of maintaining microscopes, and complaints that lecture and small-group Kodachromes were inaccessible for self-study. Two slide carousels on library reserve, some with mismatched answer keys, were grossly inadequate for a class of 168 students. Placing histology materials online gave all students instant day-and-night access to a larger collection of original histology slides for self-study, a feature used extensively prior to exams. Students manipulate online histology slides as if at a microscope, with ability to navigate around the slide and zoom in and out. A learning tool not available with a microscope is having labeled images, with overlays that can be turned on or off for self-study.

Within the histology laboratory sessions, students working in groups of two or three can concentrate on learning histologic structures, and wait to learn actual microscopy in microbiology. Faculty who previously taught the labs with original slides and microscopes note that students teach each other as they manipulate the screen images, learn how to identify structures more quickly, and are more active in their questions. Upperclass students report that they access the online materials to review for board exams, and to review images related to clinical cases.

While freestanding histology online programs provide some of the above benefits, Tufts HSDB adds powerful capabilities for any multimedia content. Students can easily search for any image, use convenient links to relevant syllabi and references, and add personal annotations to images and text that can be sorted, labeled, filed, and retrieved at any time. Faculty can create direct links to specific prerequisite course materials, reuse individual images in multiple ways, including sharing with other faculty, and store their content in a way that can be easily transferable to new technologies as they evolve. These advantages apply to all Tufts HSDB multimedia content.

Faculty-driven Tools

After the success of the histology pilot, we shifted our attention to helping faculty move syllabi online and create new materials. This phase became a prime faculty development opportunity in curriculum revision and design that has produced many benefits, some unexpected. Faculty suddenly felt peer pressure to “clean up” their syllabi before putting them online for all “tufts.edu” users. Course homepage templates focused faculty on creating stronger course objectives, leading some faculty to think more broadly about what they were teaching and whether they were providing the best methods for students to learn. Prompting faculty to think about what is better taught with multimedia on a screen versus other teaching methods has not been easy. But as we experiment with pilot projects in many courses with images, voice, video, quizzes, etc., we are learning about what works or not, and why or why not.

Revising or creating new materials requires valuable faculty time. Faculty, initially reluctant to experiment with Tufts HSDB, quickly realized that moving their content to Tufts HSDB saves precious preparation time. They no longer need to hunt for the slide carousel in which particular content is stored, but can search the database and instantly incorporate that image or text into a new presentation for a course or guest lectureship. They can also use content created by other faculty, with their permission. Since the database is Web-accessible, faculty can pull up any content “live” through an Internet line during the presentation. As faculty digitize their original slides, they can search, sort, and reuse these digital slides in multiple ways across the medical, dental, and veterinary curricula. The latter benefits cannot be overstated, particularly for faculty teaching courses in multiple schools. Faculty also realized they no longer had to worry about dropping or losing valuable original histology or pathology slides that are now archived. Faculty initially had concerns about adequate resolution for certain specimens,
but image quality has exceeded the demands of even the most discriminating faculty member.

Placing syllabi on Tufts HSDB presented different problems. Conversion of word-processed documents to good HTML was time-consuming and often focused faculty on the look of a document rather than its didactic content. To address this, the Tufts HSDB staff created the Health Sciences Curricular Markup Language (HSCML), based on XML. Used as a syllabus document structure, HSCML allows faculty to concentrate on the didactic content itself rather than on how the content is displayed. An XML-editing tool (Corel’s XMetaL) was customized to Tufts’ requirements. Now faculty log onto Tufts HSDB, check out a document, edit it, and check it back into the repository. A “content chooser” tool facilitates “drag and drop” interaction of the current document with any other Tufts HSDB content. This single XML version of the document with header and content metadata can be used in full or summary form for print, Web, or handheld device displays. With the click of a mouse, faculty can structure documents, link learning objectives, label content pearls, integrate images or text, and reference other materials.

Student-driven Tools

Tufts HSDB was created to support the learner and the curriculum. The OEA has worked closely with the Tufts HSDB team to obtain extensive student feedback through online course evaluations, focus groups, and Tufts HSDB access data to identify which particular online materials and tools help students to learn better or faster. Above anything else, access must be easy and reliable (both didactically and technically), a requirement that necessitates a close working relationship among the Tufts HSDB project staff, the OEA, and IT.

Currently, students use Tufts HSDB materials most often to review lectures or laboratory slides, student or faculty-authored review notes, old exams, and self-study quizzes. Students can now review at their leisure any lecture slides, homegrown physical exam videos, commercial educational animations on cardiac echoes, etc. For example, when learning cardiac pathophysiology, a search on “hypercholesterolemia” will yield links to biochemistry, molecular biology, nutrition, genetics, and pharmacology. As the students learn about lipid structure, they can immediately see the links to cholesterol, cardiovascular disease, and lipid-lowering drugs. Students now understand the reason they need to learn the biochemistry building block. And when they are learning about lipid-lowering drugs in pharmacology, they can easily link back to review the biochemistry if needed. Having the materials online, fully searchable, with specific faculty-guided links, allows the student more breadth and depth of learning. Faculty can “layer” information. Core information needed for “building-block” learning is on the initial screens. Links to more advanced information or related content in other courses allow those interested to pursue the topic further. Do students take advantage of this? Certainly there are those who approach learning with “Is it going to be on the test?” But many other students appreciate and take advantage of the “layering” of content, particularly as they get deeper into the curriculum.

Changing How Faculty Use Their Time with Students

Faculty initially asked if we were trying to turn medicine into a correspondence course with our online curricular tools. We
do not need to be convinced that socialization and education of students through faculty, patient, and peer contact are essential in medicine. Even outside medicine, the more successful “online or distance learning” programs, including our Fletcher School of Law and Diplomacy’s Global Master’s Program, combine face-to-face community building with online tools used in between the in-person meetings. However, given the increasing time constraints on our faculty, we must ask how to use face-to-face faculty–student time most effectively and encourage self-study with online and other materials when appropriate.

Faculty also were concerned that placing the syllabi and other course materials online would obviate the need for their live teaching. Why would students sit in a lecture hall when they can read the slides themselves on their computers at home? However, top faculty still attract a full house, and faculty are realizing that the purpose of the lecture can change. Since course materials are often quite complete, the lecture can now be used as an introduction or roadmap to the material, to elucidate broad concepts or potential stumbling blocks. Also, students no longer engage in frantic notetaking but instead engage more directly with the lecturer. Lecturers notice that they now see student faces rather than just the tops of heads. Students ask more questions and move from facts into problem solving. Do some lecturers still pack their 50 minutes with facts? Yes. But as faculty watch colleagues change teaching methods with good student response, they become more open to the idea of moving from “just the facts” to become faculty who filter, guide, challenge, and mentor.

We added another twist to lectures by adding a feedback loop with online self-assessment quizzes. We asked the pulmonary pathophysiology director to create a few online self-assessment questions for each of his lectures, with annotated answers, including links back to the syllabus. After the lecture, students were asked to take the quiz by evening. Results tabulated through Tufts HSDB were reported back to the course director that same evening. The course director quickly identified which concepts students had difficulty with—what had or had not come across in the lecture and readings. He then e-mailed further explanations to the class through the class listserv, with copies of the e-mail message sent to the lecturer and small-group leaders for the next day. Those faculty in turn reiterated those difficult concepts in their lectures and small groups before delving into new material. Faculty were energized by understanding where the students were having trouble, and students were energized by getting so much relevant information about what they were trying to learn when they were trying to learn it. Such quizzes, annotations, and links take time to create, but when coupled with faculty interaction they add educational value and excitement.

Discussion lists further facilitate faculty–student interaction. Students post questions to faculty on a discussion list linked to a course. Faculty answers immediately are available to the entire class rather than only to an individual. During pre-exam time, these lists are used extensively.

As faculty have used Tufts HSDB more in their teaching, they have become more open to dialogue about their teaching goals and to exploring the best methods to achieve those goals. The best method is not always technology. However, faculty are starting to realize that online tools can free them from certain types of teaching—certainly some of the tedious and elementary introductory material (e.g., basic facts, vocabulary) that students can easily learn on their own. Faculty can instead concentrate their energies on helping students grapple with higher-order thinking skills to understand and apply key concepts, solve problems, etc. Tufts HSDB also helps create content “threads” through the curriculum, such as with our evidence-based medicine curriculum, which starts with the first year, first semester epidemiology/biostatistics course. “Threads” of evidence-based medicine content and methods, including accessing and analyzing full-text e-journals, weave and expand through other areas of the curriculum such as nutrition, population medicine, physical diagnosis, problem-based learning, and the clerkships. Faculty are beginning to realize that they alone do not have to teach everything, since students will continue to build their knowledge as they move through the curriculum and beyond.

Faculty Dialogue and Integrated Interdisciplinary Education

Any school involved in curricular reform where a goal is to integrate content across disciplines knows how difficult the process is. The level of curricular integration that can be achieved across courses, disciplines, and years is limited mainly by the work required for faculty collaboration. An unexpected benefit of encouraging faculty to work with Tufts HSDB has been the magnitude of faculty dialogue and content integration. Faculty learn a great deal about one another’s courses and the overall curriculum simply by browsing through Tufts HSDB any time they have interest or need. This asynchronous viewing has greatly decreased the amount of face-to-face curriculum meeting time that is so difficult to schedule among busy faculty. Faculty member A, curious whether topic X is being taught, quickly can search Tufts HSDB and find all course materials on topic X—images, text, quizzes, etc.—with the faculty authors listed. Faculty member A then contacts any of those other faculty to share and coordinate content. As faculty examine one another’s content, they are discovering how their content overlaps, either redundantly or as reinforcement. With such knowledge, they are able to choose whether to keep or prune the overlapping material. Faculty maintain ownership of their
own content while showing how their content is intertwined not just across courses but across our health sciences schools.

This ongoing faculty dialogue, facilitated by the OEA, has resulted in a level of content integration and collaboration that has been much greater than expected. Tufts HSDB makes the entire process much simpler and time-efficient through its “search, view, and create” capabilities. The database approach to content storage allows the faculty to incorporate one another’s content into their own courses, whether by embedding images, text, or other building blocks into syllabi, slides, quizzes, etc., or through “hot links,” with each approach providing proper authorship attributions. Faculty can lead students studying one course to click on a link to related material in another course, weaving concepts and reinforcing material much more easily than asking students to pull out multiple syllabi. The new XML-based authoring tool mentioned earlier will provide faculty with even easier content creation and integration, with “click and drag” convenience for linking text and multimedia into a document. These tools allow extensive integration of curricular content without waiting for total restructuring of the curriculum footprint.

An example of an interdisciplinary application is a curriculum effort following the events of September 11 that illustrates the global nature of our problems and their solutions. Anthrax and other potential biological weapons are suddenly important topics in the curriculum. Searching for “anthrax” on Tufts HSDB yields content in microbiology, infectious disease, pathology, dermatology, pulmonary pathophysiology, nutrition and food safety, and public health from the medical school; and microbiology, infectious disease, sheep, public health, nutrition, and pathology from the veterinary school. Medical students can find links to veterinary course materials to learn more about animal reservoirs, and veterinary students can search through medical content to learn about human manifestations of the disease. Both groups learn about the public health implications. More curricular time to add a new course on bioterrorism does not exist. However, integration and links through Tufts HSDB allow students to learn about anthrax in one course, and access related topics across courses and schools. Interest in Tufts HSDB from the other Tufts schools adds the potential of connecting non-health sciences, bioterrorism-related content such as the political-economic context from the Fletcher School of Law and Diplomacy, and water supply and civil/environmental engineering modules from the Engineering School.

The divisions that are created to identify disciplines and departments help us to categorize and sort vast amounts of material, but in many ways are quite arbitrary. Areas such as genetics and HIV diseases do not fall into single departments. But as we teach and learn an ever-increasing body of these complicated topics, the need for information organization and management becomes essential. This is where technology is invaluable. Are we there yet? No. But with tools such as Tufts HSDB we know we are headed in the right direction.

**Issues Uncovered**

**Bringing Faculty on Board**

Faculty quickly overcame their initial concerns that the online tools were going to replace them and that we were creating “medicine by correspondence.” Yet faculty do not easily change their teaching habits unless pressures are strong, or unless a new method is “ten times better.” To tools must be easy to use, and support must be available. As tools are introduced, faculty need to learn how to use the tools most effectively in their teaching and how to translate their objectives and content into a new medium. For example, at a recent Tufts faculty development workshop, faculty from multiple schools were excited by our “teaching case shell” tool. Although faculty learned about the technical functions of the tool, they wisely recognized they had yet to learn pedagogically how to construct and use an effective case. This raised another faculty concern—the availability of time to learn new skills—particularly since most of our faculty are strictly voluntary (our medical school and hospitals are corporately separate). On the other hand, as students respond favorably to their efforts, faculty become excited about discovering new ways of teaching and learning, and they willingly commit the necessary time and effort.

Finding faculty champions willing to try out new tools encourages other faculty to use the tools. We start faculty with small, focused projects that likely will bring clear value to the faculty and students for their content areas. We reinforce skills through our university-wide faculty development teaching conferences (held twice a year since 1994), university-wide IT faculty development grants, formal course director and curriculum committee meetings, and many informal meetings among faculty with or without administration participation. In addition, our extensive curriculum evaluation system, which includes mandatory online course and clerkship evaluations by students, provides feedback from students to faculty and administration, faculty to faculty, and administration to faculty, as well as faculty self-evaluation to improve course materials and teaching methods. Models that students find helpful are easily identified and are conveyed to faculty through the evaluation system and faculty development.

**Copyright and Intellectual Property**

Tufts HSDB allows for integrating licensed and commercial content with homegrown content. Licensed full-text e-journals, textbooks, CD-ROMs, image collections, etc., are all available to students and faculty through the same system that houses the faculty-produced materials. Copyright
clearance became a frequent issue with syllabi that contained tables, figures, and pictures from multiple sources. Due to the volume and complexity of the issues, in 2001 the medical, dental, and veterinary schools agreed jointly to fund a full-time Tufts HSDB rights management staff to obtain proper copyright or find equivalent non-copyrighted materials for faculty, Tufts University has a Web page to help faculty with copyright issues, and we have held university-wide copyright workshops to educate faculty and allow discussion of specific problems encountered.

An interesting copyright or intellectual property issue that has arisen from the flexibility of Tufts HSDB has been the borrowing and “repurposing” of images by faculty. Faculty member A creates image A for course A. Faculty member B decides that image A with just a slight alteration (A’) would work very well in his course B, and therefore integrates A’ with permission from faculty member A and with identifiers showing authorship by faculty members A and B. Then faculty member C comes along, and wants to use A’ with further alterations (A”) for course C. Faculty member A decides she doesn’t like the changes in A” and no longer wants the attribution, though Faculty member B does. Such a scenario goes beyond just tracking authorship, as the image undergoes multiple revisions, and includes whether faculty even want to remain associated with an image revised in a way deemed unacceptable. Current image tracking allows cataloging of the author and date of each change, and simple “request for use” forms for faculty to request permission from each other. As content on Tufts HSDB becomes more complex and integrated, rights management that recognizes tiers of users, with diverse abilities to access and revise, becomes critical. Rights management will also play a role as Tufts HSDB builds methods to link to external publishers and digital libraries, tracking usage, and ownership.

**Budgetary Support When the Grant Ends**

Finding ongoing support after grant startup funds disappear is a major problem for many good but ill-fated projects. Cognizant of this issue, the Tufts HSDB project team nurtured broad-based, multi-school, student and faculty support. When the NLM grant ended, the health sciences schools recognized Tufts HSDB’s value to their educational missions. A Tufts HSDB steering committee was formed to provide oversight and budgetary support. The committee is composed of the Tufts HSDB project team and the educational, financial, library, and IT deans and staff from the health science schools, with the dean for IT at the medical school serving as chair. For the first post-grant year, the committee approved a basic-level budget that provided Tufts HSDB time to convince all the schools that it indeed provided a mission-critical function. Subsequent budgets have allowed both sustenance and modest growth, and for the past two years included extra funds for the full-time rights-management and user-support specialist and two additional developers. The committee meets monthly, with a budget subcommittee (educational deans, finance officers, Tufts HSDB program director, and chair) meeting quarterly. The high level of cross-school collaboration stems from all the schools’ having a common vision for the value and direction of Tufts HSDB, direct input into Tufts HSDB budget and monthly workplan, and recognition that each would be unable to support the extensive functions of Tufts HSDB on its own.

**Coordinating IT across Schools and Hospitals**

IAIMS has pushed the idea of using technology to integrate the educational, clinical, research, and administrative work of the academic health center. Our university library council brings all Tufts libraries under one umbrella to share infrastructure and holdings across the university. Our own university IT council coordinates IT services throughout the university’s three campuses, such as creating a networking infrastructure for faculty and students to communicate easily across schools, including seamless nomadic computing. Still being addressed are relationships with Tufts-affiliated hospitals that are corporately separate from the medical school, all with their own IT systems, with firewalls, internal clinical faculty directories, and intranets that are not necessarily in full communication with the Tufts network. If real patient cases are to be used for education, Health Insurance Portability and Accountability Act (HIPAA) regulations and privacy issues will be a major concern, including removing patient identifiers, as will user-authentication issues such as who has access to what data, who has viewed what data, etc. For cross-school sharing of information, the Directory of Directories in Higher Education (DoDHE), which is part of the larger Internet2 Middleware Initiative, will facilitate external users of Tufts HSDB to be easily authenticated for access to different tiers of content.

IT is expensive—the hardware, software with constant upgrades, campus network connections, etc.—but the most expensive part of any endeavor is the personnel costs: the programmers, the technical support, the educational design personnel, the content creators. However, by making good choices in system design, one can minimize costs of overhauling a system every few years to stay in line with technologic changes.

**Opportunities**

**Beyond the Medical School and Beyond Tufts**

What sets Tufts HSDB apart is not only groundbreaking work in medical education, but also being the first health
TUFTS HEALTH SCIENCES DATABASE, CONTINUED

sciences curriculum database to be used so extensively across multiple health sciences schools. In a few short years, Tufts HSDB has grown from being a pilot in the medical school to becoming a “mission critical” entity for education in the medical, dental, and veterinary schools. The Tufts Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy has come on board this year, as have several graduate degree programs on the health sciences campus. With standardized data and knowledge management of educational content, including using the National Library of Medicine’s UMLS metathesaurus common to all the health sciences disciplines, Tufts HSDB has proven itself to be easily adaptable to these varying educational cultures and content. This year (2003) we will add the subject headings from the Library of Congress that address veterinary needs even more specifically. The success across the health sciences also has led to discussions with Tufts departments in arts, sciences, and engineering.

Tufts HSDB has been designed as an open-source project to facilitate sharing, but little was known about the technical issues and support requirements associated with deployment of the Tufts HSDB infrastructure to an institution outside Tufts. For the past year, a beta-test has been under way with New York Medical College (NYMC) to help define cross-institutional issues associated with the installation of the infrastructure at another site. We demonstrated the ability to readily migrate the Tufts HSDB code base from the multi-computer Solaris UNIX installation at Tufts to a single-computer Linux platform at NYMC. Tufts HSDB also integrated easily into the technology infrastructure of NYMC, including the NYMC user-authentication system and directory services. Working with knowledgeable developers and system administrators, this joint project required only modest direct funding and limited amounts of staff time. NYMC is providing ongoing faculty development to help faculty load their content onto their own NYMC Digital Curriculum Database (DCDB) and to learn how to use available tools. The partnership of Tufts and NYMC in the development of the DCDB has added new functionality to the Tufts HSDB code base and has had a positive impact on the growth of the HSDB/DCDB at both institutions. Results of this beta-test support both the portability of the Tufts HSDB code base and the feasibility of partnering with additional institutions to develop an open-source next-generation knowledge management system to meet the curricular needs of health sciences schools.

Tufts is conducting a similar experiment with the University of Natal in Durban, South Africa, through a Fogarty grant. Tufts HSDB infrastructure will be remotely installed and configured on a server at the University of Natal Medical School. Documentation will be provided electronically and faculty will upload content to create a digital curriculum tailored to the needs of that environment. Tufts HSDB’s extension to other international health sciences institutions would be a logical next step for exploration.

The next-generation Tufts HSDB will incorporate evolving national standards to facilitate modular tool development and common access, authorization, and rights-management features. Working with standards from the Massachusetts Institute of Technology’s Open Knowledge Initiative,21 we plan to seek partners to co-develop this next-generation software. We look forward to building interfaces to a variety of digital resources such as the AAMC’s CurrMIT,22 HEAL,23 Fedora,24 and commercial information repositories.

Laboratory for a Health Sciences Learning Infrastructure

Tufts HSDB can be viewed as a pilot for what a national learning infrastructure in health sciences might look like. As in the Tufts environment, partnerships among health sciences libraries, offices of education, and information technology will be critical for success. The library is moving rapidly from traditional foot traffic into online content management and service support. Lines between “electronic reserves” and curriculum content are starting to blur, resulting in greater need to coordinate efforts between libraries and offices of education. Relationships with clinical and research databases and resources are also evolving, requiring tight coordination with the information technology arms of the university and hospital. Using common data management standards will be essential for sharing content. National initiatives by organizations such as EDUCAUSE, Internet2, and the Advanced Distributed Learning Initiative are helping to facilitate information exchange among programs and organizations.

Our system, which is in full production supporting educational programs in health sciences schools at Tufts and other institutions, is an ideal laboratory for putting developing standards into practice. We can provide ongoing feedback and refinement of the database structure, evolving data and user identification standards, user applications, and coordination issues with multi-library, multi-school, and multi-hospital interfaces.

Interdisciplinary Teaching and Learning

At the didactic level, Tufts HSDB provides powerful support for the educational trends of the integration of basic and clinical sciences, interdisciplinary teaching, and lifelong learning. To use student–faculty contact hours most effectively, faculty across disciplines must collaborate in defining the true “core content” and “key concepts” that serve as the foundation for lifelong learning. And while lifelong learning has been touted as an educational mantra for some time,
realistic has fallen short of this important goal. Students in large part are driven by how they are assessed, unfortunately still mostly by the regurgitation of facts. However, students are willing to use new learning methods if the methods help them learn faster, easier, or better. To move towards a more "graduate student" model of medical education,\textsuperscript{25} we need to change our teaching and assessment methods to increase both self-study in the basics and student-faculty contact time for problem solving, concept clarification, communication skills with patients, or researching learning questions. Online self-assessment tools can help students identify areas of weakness and lead them to faculty-guided learning materials. Faculty input is key for the student to navigate and filter extensive internal and external resources. Improved assessment of the impact of these new approaches on learning will help us to continue to refine our methods. Without a doubt, a learning infrastructure that supports truly interdisciplinary information access, problem solving, and knowledge management, and that serves as the interface of education, technology, and practice, is essential for our next generation of physicians to improve the health of the public.\textsuperscript{26}

The evolving Tufts HSDB has shown that it can provide the building blocks for such an interdisciplinary learning infrastructure. Content is managed in modular, adaptable, easily updated formats that evolve with both educational and technologic needs. The robust database structure allows us to be creative in building new user applications such as "repurposing" content for handheld devices. Tufts HSDB's ability to allow faculty across disciplines and schools to share their content in the creation of course materials is unprecedented. Recent events connected with September 11, 2001, have shown us how essential coordinated, multidisciplinary, and interdisciplinary education are to practice in the 21st century. Systems such as Tufts HSDB support this essential faculty dialogue while focusing course preparation time on content rather than style, and permit student-faculty interactions to concentrate on higher orders of learning and problem solving. Peer teaching through discussion groups, shared notes, and shared links across courses also can improve learning. Is there still room for a good book? A great lecture? Facilitated small groups? The patient interview? Absolutely. But technology will take an increasingly essential role in information delivery, access, management, and assessment.

We have the opportunity to revolutionize how medical education evolves over the coming years. This Tufts HSDB case study illustrates a promising approach to challenge and improve current teaching and learning methods, facilitate the development of interdisciplinary content, and promote cross-institutional collaboration. Successful implementation at other institutions will depend on the close collaboration of library, educational, and IT staff, and their commitment to support faculty as they learn new teaching methods. We welcome inquiries from other schools that may be considering, or are already involved in, the creation of the next-generation open-source knowledge-management system for the health sciences. Much work remains, but we look forward to and are ready for the challenges ahead.

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References

Note: Descriptions of various terms in this list (e.g., those in items 2, 3, and 4) were written in part by the authors.


